
RFI Report
Van Waters & Rogers Inc.
4120 Buckingham Place
Omaha, Nebraska
EPA ID # NED986375327

REC'D
DEC 01 1999
RCAP

Prepared for:

Van Waters & Rogers Inc.
6100 Carillon Point
Kirkland, Washington 98033

November 1999

Project No. 004133.000.0

Volume 1 of 5

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R00151111
RCRA RECORDS CENTER

Geomatrix Consultants

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November 30, 1999
Project 004133.000.0

REC'D

DEC 01 1999

RCAP

Mr. William F. Lowe
U.S. Environmental Protection Agency
901 North 5th Street
Kansas City, KS 66101

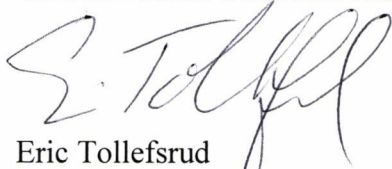
Subject: Final Report, RFI
Van Waters & Rogers Inc., 4120 Buckingham Place Facility
Omaha, Nebraska
EPA ID# NED986375327

Dear Mr. Lowe:


Enclosed you will find two copies of the Final RFI Report. This report is submitted on behalf of Van Waters & Rogers Inc.

If you have any questions, please do not hesitate to contact Jim Hooper at VW&R, 630-761-0486 or Eric Tollefsrud at 612-544-4614.

Sincerely yours,
GEOMATRIX CONSULTANTS, INC.



Eric Tollefsrud
Senior Hydrogeologist



Gary Hokkanen
Principal Hydrogeologist

ET:ke

Enclosure

cc: Mr. Jim Hooper, Van Waters & Rogers Inc.
Ms. Virginia Cavadias, Omaha Public Library
Mr. Bill Gidley, Nebraska Department of Environmental Quality

Geomatrix Consultants, Inc.
Engineers, Geologists, and Environmental Scientists

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Mr. James Hooper
66 Feece Drive
Batavia Il. 60510

RE: Univar, Buckingham Place, Omaha Nebraska
EPA ID# NED986375327

Dear Mr. Hooper:

The Environmental Protection Agency has completed review of the revised volume 1 of the RCRA Facility Investigation Report dated November, 1999 (RFI.). The revisions in this report address all comments in our letter to Van Waters and Rogers dated November 19, 1999.

The RFI , consisting of the revised volume 1 and the draft volumes 2 through 5, is approved with the following clarification: The third sentence of the last paragraph of Section 9.2.2 states that there is no exposure to groundwater contaminants of concern (COC's) at Spring Lake Park. The EPA agrees that there are currently no exposures to COC's at Spring Lake Park.

If you have any questions, call me at (913) 551-7547.

Sincerely,

William F. Lowe
Project Coordinator
RCRA Corrective Action and Permits Branch
Air, RCRA, and Toxics Division

cc: Bill Gidley
Nebraska Department of Environmental Quality

bcc: David Hoefer
CNSL

Ed Hubert
PRC

**RFI Report
Van Waters & Rogers
4120 Buckingham Place**

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EPA ID # NED986375327

Prepared for:

Van Waters & Rogers Inc.

6100 Carillon Point

Kirkland, Washington 98033

Prepared by:

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Geomatrix Consultants

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ACRONYMS and ABBREVIATIONS

µg/l	Micrograms per Liter
1,1,1-TCA	1,1,1-Trichloroethane
ASTM	American Society for Testing and Materials
bgs	Below Ground Surface
CAS	Columbia Analytical Services, Inc.
CMS	Corrective Measures Study
COC	Constituent of Concern
COPC	Constituent of Potential Concern
cm/sec	Centimeters per Second
DAF	Dilution Attenuation Factor
DCC	Description of Current Conditions
DCE	cis-1,2-Dichloroethene
DCQAP	Data Collection Quality Assurance Plan
DO	Dissolved Oxygen
Facility	4120 Buckingham Place, Omaha, Nebraska
gpm	Gallons per Minute
I	Intermediate
IRIS	U.S.EPA Integrated Risk Information System
IRM	Interim Remedial Measure
ISC	Intermediate Screening Criteria
K _{sat}	Saturated Hydraulic Conductivity
K _{unsat}	Unsaturated Hydraulic Conductivity
mB	Millibars
MCL	Maximum Contaminant Level
mg/kg	Milligrams per Kilogram
mm	Millimeter
NCDC	National Climatic Data Center
NGVD	National Geodetic Vertical Datum
ORP	Oxidation-Reduction Potential
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethene
PEF	Particulate Emission Factor
PID	Photoionization Detector
PRG	U.S.EPA Region IX Preliminary Remediation Goal
QA/QC	Quality Assurance/Quality Control
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RfD	Reference Dose
RFI	RCRA Facility Investigation
RPD	Relative Percent Difference
RTDF	Remediation Technology Development Forum
SVOC	Semivolatile organic compound
S	Shallow

ACRONYMS and ABBREVIATIONS

(continued)

SSLair	Soil Screening Levels for Transfer from Soil to Air
SSLgw	Soil Screening Levels for Transfer from Soil to Groundwater
TCE	Trichloroethene
TCL	Target Compound List
TOC	Total Organic Carbon
UCL	Upper Confidence Limit
USCS	Unified Soil Classification System
U.S.DA	United States Department of Agriculture
U.S.EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
VW&R	Van Waters & Rogers Inc.
WDCC	Warren Douglas Chemical Company
XSD	Halogen-Specific Detector

RFI REPORT

Van Waters & Rogers Inc.
4120 Buckingham Place
Omaha, Nebraska
EPA ID # NED986375327

1.0 EXECUTIVE SUMMARY

Van Waters & Rogers Inc. (VW&R) has completed an investigation of environmental conditions at its former industrial Facility located at 4120 Buckingham Place, Omaha, Nebraska (the "Facility") to evaluate the need for an environmental cleanup. The investigation has been conducted under an agreement with the U.S. Environmental Protection Agency (U.S. EPA) following the Resource Conservation and Recovery Act (RCRA) corrective action investigation process. This report presents the findings of the RCRA Facility Investigation (RFI) and supports the development and evaluation of cleanup options.

The RFI characterizes the environmental setting, the type, level, and location of constituents of potential concern (COPCs) in environmental media, and the potential risk that may be posed by the COPCs to human health and the environment. The environmental setting was characterized primarily through observations of soil and groundwater conditions. Soil conditions were observed by drilling a number of soil borings and groundwater conditions were observed by measuring the occurrence and level of groundwater in wells and piezometers installed in various strata encountered at the Facility. Soil and groundwater samples were collected at numerous locations and tested for the presence and concentration of volatile organic compounds (VOCs), pesticides, semivolatile organic chemicals (SVOCs), metals, dioxins, and polychlorinated biphenyls (PCBs). The chemical test results were compared to risk-based criteria established by the U.S.EPA to identify if any of the COPCs may pose a risk to human health and the environment. Where a potential risk was indicated by this comparison, the risk was assessed by finding where people may be exposed to the COPCs in soil or groundwater and under what conditions they may be exposed. Ecological risks were also evaluated. Finally, the assessment included estimating constituents of concern (COC) concentrations at which exposure may result in a health risk above levels generally considered acceptable by regulatory agencies, and identifying areas that may contain those concentrations under current or future conditions.

Results of the RFI indicate that exposure to VOCs and pesticides in soil through incidental ingestion, dermal contact, or inhalation of vapors or resuspended soil particulates (i.e., dust), may pose a potentially unacceptable risk to future industrial workers at the Facility. When compared to other COCs detected in the soil, two pesticides, aldrin and dieldrin, were found to pose the greatest potential risk to human health. The highest concentrations of these chemicals were detected in the southwestern portion of the Facility, west of the road that bisects the Facility. Levels of COCs in soil east of the road do not appear to pose an unacceptable risk to human health. In 1991, VW&R covered most of the area of soil affected by pesticides and VOCs by installing a liner and gravel cover. This liner and gravel cover remains in place and prevents exposure to the affected soil. Exposure would only be possible if the liner and gravel cover were removed in the future.

The level of risk associated with COCs in groundwater is limited because groundwater is not used in the affected area. Furthermore, groundwater development in the area is restricted by City ordinance and is unlikely in the future. This area of the City has long been developed and is serviced by a municipal water supply. The source for the municipal water supply is distant from the Facility, and the Facility does not pose a risk to this supply. Downgradient surface water bodies may present a potential receptor. This was evaluated during the RFI and it was found that groundwater that appears to discharge to the surface over a mile from the Facility at Spring Lake Park is not affected by COCs. The data suggest that COCs attenuate along the relatively lengthy groundwater flowpath before reaching the Spring Lake Park area. Risk to future groundwater users and downgradient surface water bodies can be eliminated by preventing future exposure to affected groundwater or, to the extent necessary, addressing future migration of impacted groundwater toward the potential receptors.

Several cleanup options for addressing identified risks are presented in this report, based on the environmental setting, the characteristics of the COCs, and the nature of the risk posed to human health and the environment. The results of the RFI form a foundation to evaluate these alternatives during the next step in the RCRA corrective action process, which is the performance of a Corrective Measures Study (CMS). The CMS will evaluate alternative solutions to reduce risk to human health and the environment by removing, containing, or otherwise addressing the COCs, and will propose and recommend one or more technological or institutional solutions with respect to the COCs.

2.0 INTRODUCTION

The RFI was conducted by Geomatrix Consultants, Inc. (Geomatrix) on behalf of VW&R in accordance with the RFI Work Plan approved by the U.S. Environmental Protection Agency (U.S. EPA) pursuant to an April 27, 1993, Administrative Order on Consent (Docket No. VII-93-H-0011) (Order) (U.S. EPA, 1993) entered into between the U.S. EPA and Univar Corporation, which owned the Facility at that time. In 1996, the Univar Corporation changed its name to Pakhoed Distribution Corporation. VW&R is a wholly-owned subsidiary of Pakhoed Distribution Corporation, a Washington corporation.

The RFI was conducted in a phased approach. The four phases of the RFI Work Plan include the following: 1) the Revised RFI Work Plan (Geomatrix, 1997a), 2) the Addendum to the RFI Work Plan (Geomatrix, 1997b), 3) the Off-Site Work Plan (Geomatrix, 1998a), and 4) the Work Plan Addendum 2 for Off-Site Groundwater Assessment (Geomatrix, 1999). This RFI Report provides the methodology, data, analysis of results, and conclusions from the work performed pursuant to the phased Work Plan. Data from the Facility were collected in 1990 and 1997-99.

2.1 PURPOSE OF THE RFI

The RFI was conducted to characterize the nature and extent of releases of hazardous waste and/or hazardous constituents (COPCs) at the Facility. This included characterizing the environmental setting, the type, level, and location of COPCs in environmental media, and the risk that may be posed by the COPCs to human health and the environment. The results of the RFI are used to determine if a corrective measure is necessary.

2.2 ORGANIZATION

This report is organized in the following manner. Section 1.0 presents an executive summary. Section 2.0 contains introductory information and Section 3.0 presents background information relevant to the RFI. The background information includes current and former Facility conditions, a summary of previous investigations, a description of areas of concern, and a list of COPCs. The voluntary interim remedial measures undertaken by VW&R are described in Section 4.0.

The technical approach of the RFI, that is, the strategy utilized to collect data on the environmental setting, magnitude and extent of COPCs, and potential receptors, is described in Section 5.0. Where Section 5.0 presents the broader overview and the logic of the RFI, Section

6.0 details the specific methodologies that were utilized. For example, a detailed description of the manner in which soil samples were collected and analyzed is presented in Section 6.0.

Results of the RFI data collection efforts are presented in Section 7.0, including findings regarding the environmental setting, type, level and location of COPCs, and potential human or ecological receptors for COPCs. The data are characterized with regard to the risk posed to human health and the environment in Section 8.0.

Conclusions from the RFI are presented in Section 9.0. In addition, potential corrective measures technologies that apply to the Facility conditions are listed in Section 9.0. References are listed in Section 10.0.

3.0 BACKGROUND

Specific geographic areas of concern and COPCs were identified based on background information, and this information was used to design the technical approach for the RFI. This section updates the information presented in the Revised Description of Current Conditions (DCC) Report (Geraghty & Miller, 1996). Included are a summary of current conditions at the Facility, a description of former Facility conditions, and the scope of work and conclusions of the Phase I Investigation. The Phase I Investigation was conducted in July 1990 as a followup to a RCRA Facility Assessment (RFA) conducted by the U.S.EPA during August 1989. The purpose of the Phase I Investigation was to assess the possible presence of COPCs in areas of concern identified during the RFA. The need for the RFI was based on the results of the Phase I Investigation.

3.1 CURRENT FACILITY CONDITIONS

The Facility was closed and decommissioned in 1989, when VW&R commenced operations at a new facility at the adjacent property located at 3002 "F" Street. Current Facility conditions are relatively unchanged from those reported in the DCC Report (Geraghty & Miller, 1996). No significant changes have occurred at the Facility since 1991. Facility property is currently used to access VW&R's adjacent operating Facility.

3.1.1 Facility Location and Description

The Facility is located at 4120 Buckingham Place in the southern portion of the City of Omaha in Douglas County, Nebraska (Figure 1). The Facility is located on roughly rectangular property approximately 2.2 acres in size. F Street forms the northern boundary of the property, passing overhead on a four-lane concrete/blacktop viaduct. G Street forms the southern

boundary of the property. A railroad siding is located near the Facility's western boundary. The eastern boundary of the Facility faces a vacant lot.

All structures at the Facility were dismantled and removed by Univar in 1990 and 1991 (Univar, 1992a, 1992b). The only remaining structures are the concrete foundations of some of the buildings (Figure 2), a storm sewer in the southeastern part of the Facility, the paved access road to the adjacent operating VW&R Facility, and a fence surrounding the Facility. Most of the ground surface is covered with a Permalon liner and gravel.

3.1.2 Access to the Facility

The Facility is accessible from the south via G Street. A paved road extends from G Street through the middle of the Facility, dividing the Facility into roughly eastern and western halves. The current layout of the Facility is illustrated on Figure 2. VW&R has an easement for access to their adjacent Facility via the paved road. Access to the Facility is controlled by a chain link fence that completely encircles the Facility (Figure 2). Gates in the fence at the northern and southern ends of the Facility are open during the day to allow traffic access to the adjacent VW&R Facility. The southern gate is locked at night.

3.1.3 Surrounding Land Use

The Facility is surrounded by industrial and/or commercial properties on the north, west, and south and by residential properties on the east. Adjacent industrial properties are VW&R to the north, the Union Pacific railroad to the west, Val's Self-Storage to the south, and Weathercraft Roofing Company to the south. The Facility is zoned heavy industrial by the City of Omaha.

Property east of the Facility is residential. The residences closest to the Facility are located on 29th Street between E and H Streets, approximately ½ block from the Facility. There is a vacant property between the Facility and the closest residences. The residential properties are uphill from the Facility. Six schools are located within a one-mile radius of the Facility. The closest is St. Bridgets school, which is approximately ¼ mile to the east of the Facility, on the opposite side of a four-lane divided highway, the Kennedy Expressway (U.S. Highway 75). The residences and schools are located at a higher elevation than the Facility. The schools and residences are serviced by city water.

3.2 FORMER FACILITY CONDITIONS

The Facility was used for chemical repackaging and blending beginning in 1954. Prior to this, the Facility appears to have been used as railroad yardage (Geraghty & Miller, 1996). In 1954,

the Warren Douglas Chemical Company (WDCC) acquired the property along with what is now the adjacent VW&R operating Facility property.

3.2.1 1954 to 1980

From 1954 through 1980, WDCC conducted chemical distribution operations at the Facility. This included the following operations:

- Repackaging mineral acids and solvents
- Blending various paint thinners
- Blending disinfectants, insecticides and other agricultural chemicals including aldrin, heptachlor, and pentachlorophenol
- Blending mineral oils and feed additives
- Reclaiming solvents, including acetone, carbon tetrachloride, alcohols, and naphtha.

In 1955, a fire and explosion occurred in the warehouse at the Facility. The warehouse was located in the approximate location of Former Warehouse No. 1 (Figure 3), which was constructed by WDCC following the fire and explosion. There is no record of specific materials having been released or specific response actions having been taken concerning the fire. Most of the structures present when the Facility was decommissioned in 1989 (Figure 3) were apparently constructed by WDCC following the fire and explosion (Geraghty & Miller, 1996). There is no documentation regarding the volume or composition of the waste stream from the facility prior to 1980 (Geraghty & Miller, 1996).

3.2.2 1980 to 1989

In 1980, VW&R acquired the Facility from WDCC by merger. Soon after the acquisition, VW&R constructed an L-shaped concrete block building immediately north of Former Warehouse No. 1 (Figure 3). This building, the former corrosive repack/office building, provided space for corrosive drumming, tank washing, and office space. In addition, VW&R constructed a new corrosive storage area immediately north of this new building (Figure 3). VW&R eliminated the blending and repackaging of pesticides that had been performed by WDCC.

VW&R conducted a mineral acid and solvent repackaging process that generally consisted of transferring chemicals from bulk storage tanks into smaller containers. The chemicals from bulk storage tanks were pumped through fixed piping into the repackaging areas. Flexible

hoses with stainless-steel filling wands were generally used to transfer the chemicals from the fixed pipes to the individual containers. The repackaging areas at the Facility included the former corrosive repack/office building, Former Warehouses No. 1 and No. 2, the former solvent storage building, and the former shed. The waste stream from the repackaging process was comprised of approximately 2,500 gallons per week of corrosive washwater. The washwater was neutralized and discharged to the sanitary sewer (Geraghty & Miller, 1996).

3.2.3 1989 to 1991

VW&R ceased all operations at the Facility in 1989. In 1990, VW&R transferred ownership of the Facility to Univar, its parent corporation. Univar demolished and removed the existing structures and disposed of the debris in 1990 and 1991 (Univar, 1992b).

3.3 PHASE I INVESTIGATION

Several areas of stained soil and several containment systems that exhibited evidence of a lack of integrity were observed during the RFA conducted in August 1989 (PRC Environmental Management Inc., 1992). These areas were investigated during the Phase I Investigation conducted during July 1990 by Harding Lawson Associates (HLA) for Univar (HLA, 1991). The investigation consisted of drilling 14 soil borings and collecting 45 subsurface soil samples and 7 surface soil samples. Soil samples were collected from depths as great as 65 feet below ground surface (bgs). In addition, 10 asphalt/concrete samples were collected. A total of 62 investigative samples were collected from areas where surface conditions such as staining or fractured concrete or asphalt suggested a potential for releases of COPCs to the environment. Sample collection locations are illustrated on Figure 4; samples collected during the Phase I Investigation have a "BP" prefix.

The samples were tested for the presence of VOCs, SVOCs, pesticides, PCBs, and metals. This included analyzing 43 of the 62 investigative samples for VOCs on the target compound list (TCL), all 62 samples for SVOCs on the TCL, 43 of the 62 samples for pesticides and PCBs, and all 62 samples for metals. Asphalt/concrete samples were not analyzed for VOCs. Samples collected from depths greater than 10 feet bgs were not analyzed for pesticides or PCBs. Several COPCs were detected in the asphalt/concrete and soil samples, including VOCs, SVOCs, pesticides and metals. These results supported the conclusion that an RFI was necessary and indicated areas of concern.

The results of the Phase I Investigation were used to plan the RFI and to supplement data collected during the RFI. Because the Phase I data are used to address objectives of the

investigation, the data are presented in this report alongside RFI data for completeness and clarity. The Phase I data meet the data quality objectives presented in the quality assurance project plan for the RFI (Geomatrix, 1997a).

3.4 AREAS OF CONCERN

The former use of the Facility, findings of the RFA, and the results of the Phase I investigation were used to identify 14 areas of concern to be investigated during the RFI (Figure 3). The areas of concern were as follows:

1. Former drum washing area
2. Former corrosive storage area
3. Former catch basin and sump
4. Former mineral oil tanks
5. Former Warehouse No. 1
6. Former Warehouse No. 2
7. Outfall ditch
8. Former product piping
9. Former solvent storage building
10. Former solvent storage area
11. Former satellite accumulation area
12. Former container storage areas
13. Former corrosive repack room
14. Former shed.

The areas were observed to have a similar potential for release and similar COPCs. Because of the contiguous nature of the areas and the small size of the Facility, the areas of concern were viewed as one rather than 14 discrete areas in the context of the RFI. These areas are described in detail in the DCC Report (Geraghty & Miller, 1996). The information presented in the DCC Report includes a waste characterization for each area of concern, in accordance with the Order. The areas of concern were all decommissioned in 1990.

3.5 CONSTITUENTS OF POTENTIAL CONCERN

The initial list of COPCs at the Facility used in the RFI included the VOCs, SVOCs, pesticides, PCBs, and metals listed in Table 1. This list was based on the former operations at the Facility and on the results from the Phase I Investigation. Characterizing the type, level, and location of COPCs was a primary focus of the RFI. The list of COPCs was refined based on a comparison of detected concentrations with risk-based criteria established by the U.S. EPA to a list of constituents of concern (COCs).

4.0 VOLUNTARY INTERIM REMEDIAL MEASURES

Univar undertook a voluntary interim remedial measure (IRM) at the Facility in 1991. The IRM addressed the results of the Phase I Investigation that indicated the presence of COPCs in soil at concentrations that may pose an environmental concern. The purpose of the IRM was to reduce the potential impact of the COPCs on human health and the environment (Univar, 1992a, 1992b).

The IRM consisted of the following response and mitigation measures: removal of aboveground structures, installation of fencing, repair of remaining surface concrete, and capping of exposed soil with a Permalon liner and gravel cover. The fence encloses the areas of concern and the Permalon liner covers most of the Facility not already covered by concrete foundations or the asphalt-paved road.

5.0 TECHNICAL APPROACH

The scope of the RFI consisted of characterizing the environmental setting, the type, level, and location of COPCs in environmental media, and the risk that may be posed by the COPCs to human health and the environment. The scope of work was addressed through the technical approach described in the following sections.

5.1 ENVIRONMENTAL SETTING

The environmental setting was characterized by collecting data on soil, groundwater, surface water, and climate conditions, as described in the following sections.

5.1.1 Soil

The hydrostratigraphy and hydrologic parameters of the unconsolidated material underlying the Facility was characterized by describing and testing soil samples collected from soil borings. In addition, published literature regarding the geology of the area was used in the analysis of

hydrostratigraphic conditions (Miller, 1964). The soil borings drilled for the Phase I Investigation in 1990 and the RFI in 1997-99 are listed in Table 2. In addition, geologic data from other drilled holes in the area were used in characterizing the hydrostratigraphy. Other drilled holes include two test borings drilled by the Nebraska Department of Roads underneath the F Street viaduct (Nebraska Department of Roads, 1980) and three soil borings drilled for an RFI at the adjacent VW&R Facility (Geomatrix, 1998b).

There have been five phases of soil borings at and near the Facility, beginning with the Phase I Investigation in 1990 through completion of the RFI in 1999. Observations made during drilling were used to characterize the hydrostratigraphic column to the depth of the uppermost significant water-bearing unit. Several borings were drilled to assess the thickness and hydrogeologic characteristics of this water-bearing unit, and the confining unit that underlies it. Drilled depths varied by location because of variation in surface elevation. At the Facility, the deepest borings were approximately 100 feet in depth. At off-site locations southeast of the Facility where the surface elevation was higher, borings extended to as much as 129 feet in depth.

The first phase of drilling was during the 1990 Phase I Investigation. These borings were terminated before the uppermost water-bearing unit was encountered. The second phase of drilling was conducted pursuant to the U.S.-EPA-approved work plan in April-June 1997, and included drilling to depths as much as 77 feet bgs at the following seven on-site locations:

- BSS4
- BSS8
- BSS18
- BSS21
- BSS26
- BSS32
- BSS33.

Groundwater was encountered during this phase of drilling. The second phase of drilling also included drilling relatively shallow borings (i.e., less than 15 feet bgs) at locations BSS1 through BSS31, primarily to collect geochemical data.

The third phase of drilling was in October 1997 and included drilling five soil borings to construct groundwater monitoring wells (MW1I through MW3I, MW4S and MW4I). These five borings provided hydrostratigraphic data to depths as much as 90 feet bgs. In addition, relatively shallow borings were drilled at 16 off-site sampling locations (BSS35 through BSS50), primarily to collect geochemical data.

The fourth phase of drilling, in July 1998, included two off-site boring locations, BSS51 and BSS52, which extended approximately 127.5 feet bgs. The off-site borings were drilled to determine a location for monitoring well MW7I. Three soil borings were also drilled for the construction of monitoring wells MW5I, MW6I, and MW7I during the fourth phase. The boring for MW7I extended to approximately 119 feet bgs, while the other two borings were drilled to approximately 96 feet bgs.

The fifth phase was in March 1999, when borings were drilled for the installation of off-site monitoring well MW8I and off-site temporary piezometers PZ1, PZ2 and PZ3, which were located near Spring Lake Park. The borings for the temporary piezometers were used to correlate hydrostratigraphy in a downgradient location with the hydrostratigraphy at the Facility.

During the Phase I Investigation, soil samples were collected at 5- to 10-foot intervals to provide soil classification data, which was recorded on boring logs (HLA, 1991). During the RFI, soil samples were collected continuously during drilling and described by a geologist to provide soil classification data. The soil classification data were correlated between drilled holes to interpret the hydrostratigraphy underlying the Facility.

Samples from each of the stratigraphic units encountered during drilling were tested for the hydrologic parameters listed in Table 3. In addition, hydrologic test results for samples collected at the adjacent VW&R Facility were used in characterizing the hydrology of the strata underlying the Facility.

5.1.2 Groundwater

Groundwater conditions were observed by measuring the occurrence and level of groundwater in nine monitoring wells, six at the Facility and three off site. In addition, three temporary piezometers were installed at off-site locations near Spring Lake Park, approximately one mile east of the Facility. Information regarding regional groundwater conditions was gathered from

published literature (Miller, 1964; University of Nebraska, 1986; Burchett and Carlson, 1966; U.S. Geological Survey [U.S.GS], 1984) including:

- Depositional history
- Identification and characterization of areas of recharge and discharge
- Regional groundwater flow pattern
- Topographic features that might influence the groundwater flow system.

Hydraulic parameters such as hydraulic conductivity and porosity were estimated based on hydrologic test results. Groundwater level measurements were used to plot a hydrograph of water levels as a function of time and to plot maps illustrating groundwater elevations, flow direction, and hydraulic gradient.

Monitoring wells MW1I, MW2I, MW3I, MW4S, and MW4I were installed at the Facility in October 1997. Monitoring well MW5I was installed at the Facility and MW6I and MW7I were installed off site in July 1997. MW8I was installed off site in March 1999, as were temporary piezometers PZ1, PZ2, and PZ3. Monitoring wells with an "I" suffix are screened in a water-bearing sand unit that appears to be the uppermost continuous water-bearing unit. MW4S is screened approximately 18 feet higher in elevation, in a discontinuous water-bearing unit. The location of the monitoring wells is illustrated on Figure 2. Water levels were measured in the monitoring wells on an approximately monthly basis to characterize temporal fluctuation in groundwater conditions.

5.1.3 Surface Water

The surface runoff at the Facility was described in detail from observations made at the Facility. As documented in the DCC Report, there is no surface water at or adjacent to the Facility, other than ephemeral flow in drainageways following rainfall or during snowmelt. Observations made during the RFI included the location of drainageways, sewers, and culverts, a description of any runoff present, the circumstances surrounding the presence of runoff, and a description of the general origin of the runoff. Surface water conditions are described in section 7.1.3 of this report.

5.1.4 Climate

Climate was characterized by compiling data from Eppley Field, which is located in northeastern Omaha.

5.2 CONSTITUENTS OF POTENTIAL CONCERN

Soil and groundwater samples were collected at numerous locations and tested for the presence and concentration of the COPCs listed in Table 1. A COPC is a chemical that has the potential, based on the available information, to be detected at concentrations that may require corrective action. The concentration and location of COPCs was a primary subject of the investigation. As the investigation progressed and chemical test results became available, some groups of chemicals were no longer considered COPCs or chemical test parameters because their concentrations were below generic risk-based criteria. For example, when SVOCs were not detected above generic risk-based criteria in the first phase of the investigation, SVOCs were not retained as COPCs during subsequent phases, such as off-site soil sampling. However, because VOCs were detected above generic risk-based concentrations in shallow soil, VOCs were retained as COPCs during testing of deep soil samples and during testing of soil samples collected off-site. The same approach was followed during groundwater chemical testing.

The chemical test results for COPCs were further evaluated during the risk characterization by comparison to site-specific risk-based criteria to arrive at a list of COCs that require corrective action.

5.2.1 Soil Gas

Soil gas sampling had been tentatively planned as a tool for assessing potential releases of volatile COPCs at the Facility. The feasibility of soil gas sampling was tested prior to full-scale implementation. Under Facility conditions at the time of the test in April 1997, a soil gas sample could not be extracted from the clayey silt in the subsurface under attainable vacuum pressures. Therefore, a program of soil sampling was conducted instead, in accordance with the RFI Work Plan.

5.2.2 Soil

Sampling locations, illustrated in Figure 4, were selected to target areas of concern and to evaluate the magnitude and extent of COPCs for those areas of concern. The total depth of sampling for chemical analysis at each sample collection location was determined during the course of the work by screening samples for the presence and concentration of indicator parameters. Indicator parameter analysis was conducted on site so that data were available for sampling decisions while sampling was ongoing. The indicator parameters for the RFI were selected based on 1990 Phase I Investigation results, the former use of the Facility and estimates of the constituents most likely to be present in the subsurface. The indicator parameters included acetone, toluene, trichloroethene (TCE), and tetrachloroethene (PCE). The

detected concentrations of indicator parameters were compared to risk-based criteria to define the scope of soil sampling. Risk-based concentrations (RBC) and soil screening levels for transfer from soil to groundwater (SSLgw) (U.S.EPA, 1997a) were used as the risk-based criteria. If soil concentrations were below the RBC and the SSLgw, sampling was terminated at that location. RBC and SSLgw values for the four indicator parameters are included in Appendix A.

RBCs represent soil concentrations associated with either a one-in-one million (1×10^{-6}) excess cancer risk (for carcinogens) or a hazard index of one (for noncarcinogens) based on default assumptions regarding exposure to soil under a residential scenario. Because the Facility is in an industrial-use area and has a planned future industrial use, the comparison of soil data to the residential RBCs (which are lower than industrial RBCs) provided an added level of conservatism. SSLgw values represent soil concentrations protective of groundwater based on default assumptions regarding the potential leaching of a chemical from soil to groundwater. The SSLgw values that were used include a default 10-fold dilution/attenuation factor (DAF).

5.2.3 Groundwater

Water-bearing units were encountered at approximately 70 feet bgs. This observation, coupled with results that indicated that the magnitude and vertical extent of COPC concentrations in soil were sufficient to potentially impact groundwater by transfer from soil to groundwater (i.e., the SSLgw values were exceeded), necessitated an assessment of groundwater conditions. This included characterizing the type, location, and level of COPCs in groundwater.

Groundwater samples were collected on an approximately quarterly basis beginning in 1997 from the nine monitoring wells installed for the RFI (Figure 2) and analyzed for COPCs. In addition, groundwater samples were collected from two soil borings drilled at an off-site, downgradient location in 1998, and analyzed for COPCs. The samples were collected on a vertical profile within the uppermost continuous water-bearing unit to characterize the extent and distribution of COPCs in groundwater within the unit and to select the interval for the well screen in MW7I. Groundwater samples were also collected from three temporary piezometers installed in the Spring Lake Park area, off-site and approximately one mile hydraulically downgradient of the Facility, in March 1999. These samples were analyzed for COPCs to assess if groundwater that potentially discharges to springs in the area contained COPCs.

The capacity of the aquifer to attenuate COPCs was characterized by testing groundwater for a suite of analytical parameters referred to as attenuation parameters (U.S.EPA, 1997b). The

suite of parameters included dissolved oxygen, reduced iron, manganese, oxidation-reduction potential, sulfate, chloride, and nitrate. This information was used to evaluate the migration and distribution of COPCs in groundwater within the water-bearing units and the potential for future migration (U.S.EPA, 1999a; Remediation Technology Development Forum [RTDF], 1999).

5.3 RISK CHARACTERIZATION

The chemical test results for soil were used to characterize the potential risk posed to human health. First, the test results were compared to human health risk-based criteria to identify which of the initial list of COPCs are present in soil at concentrations that might pose an unacceptable risk to human health. A comparison of Facility data to the risk-based criteria was enough to conclude that some corrective action will be necessary for soil; therefore, no baseline risk assessment was conducted. Second, intermediate screening criteria (ISC) were developed for the COPCs in soil that exceeded the risk-based criteria. ISCs are estimated concentrations of constituents in the soil that are protective of human health over a lifetime of exposure. The future use of the Facility is expected to be industrial. For future industrial use, the Facility would need to be redeveloped entailing short-term construction and utility work. The assumptions and default values used to calculate ISCs for a long-term industrial worker were compared to those for a short-term on-site construction/utility scenario. This comparison is discussed in Section 8.1.6 and shows that the ISCs for an adult industrial worker are protective of a construction/utility worker. Therefore, the ISCs were based on an adult industrial worker scenario.

ISCs were used to identify areas of soil at the Facility that may require corrective action to reduce the health risk to an acceptable level. Finally, the residual health risk was calculated assuming that the identified area of concern was addressed by corrective action. The residual risk level was then compared against risk levels generally considered acceptable by the U.S. EPA. If the residual risk was not acceptable, the area assumed to be addressed by corrective action was enlarged, and the residual risk was recalculated. This iteration was continued until an acceptable residual risk level was produced. An area of soil to be addressed by corrective action was identified through this process.

The assessment of risk related to groundwater impacts included characterizing local uses and possible future uses of groundwater. The maximum detected groundwater concentration for each detected chemical was compared to U.S. Safe Drinking Water Act maximum contaminant levels (MCLs). As noted earlier, it is extremely unlikely that groundwater would be used for

any purpose in the vicinity of the Facility. However, this provided a method for identifying COPCs for further evaluation. COPCs were further evaluated by identifying potential receptors for groundwater, and the potential exposure pathways for those receptors.

The assessment of ecological risk included a description of the ecology overlying and adjacent to the Facility and a description of any endangered or threatened species at or near the Facility.

6.0 METHODOLOGY

The methodologies employed to implement the technical approach are described in this section. This includes methodologies for collecting data regarding soil gas, soil, groundwater, surface water, climate, and potential receptors.

6.1 PILOT TEST OF SOIL GAS SAMPLING

A soil gas sampling pilot test was performed on April 22, 1997. Soil gas sample collection was attempted by connecting a length of polyethylene tubing to a retractable soil gas probe inserted approximately 15.5 feet bgs at four locations. The soil gas probe was inserted using a direct-push sampler operated by Matrix Technologies, Inc., of Osseo, Minnesota. A vacuum ranging from seven to fifteen pounds of water was applied to the probe. One-quarter liter of air was evacuated from the system to remove the ambient air within the tubing and sampling apparatus. Next, the down hole tubing was connected to an empty, valve-regulated, Tedlar bag. A vacuum was applied to the bag for up to five minutes. It was observed that under Facility conditions at the time of the tests, soil gas samples could not be extracted from the subsurface under attainable vacuum pressures. Soil gas sampling was determined not to be feasible, and instead, shallow soil borings were advanced, in accordance with the Work Plan.

Prior to collecting subsurface data, sampling devices were thoroughly decontaminated with distilled water and soap wash and then distilled water double rinse or steam cleaned and distilled water double rinsed. Sampling devices were decontaminated between sample collection intervals and between sampling locations. These decontamination procedures were used during all subsurface sampling or drilling activities.

6.2 SOIL SAMPLING

Data regarding soil conditions were obtained by observing and testing soil samples collected from boreholes. Boreholes were drilled by using direct-push sampler, hollow-stem auger, and rotasonic drilling methods. A power hand auger was used during the Phase I Investigation.

Table 4 summarizes the drilling methodology used for each borehole advanced during the RFI and the Phase I Investigation. The methodology for drilling, soil sample description, and quality control/quality assurance (QA/QC) is discussed in this section.

6.2.1 Direct-Push Sampler

The direct-push sampler used in April 1997 consisted of a 2-foot long, one-inch diameter steel tube fitted with a clean, disposable acetate liner. The sampler was pushed to a depth of approximately 12 feet bgs to collect one soil sample from each location for chemical analysis. Upon retrieval of the soil sample, the acetate liner was capped, labeled and stored on ice until the sample was chemically analyzed.

The direct-push sampler used in October 1997 consisted of a 4-foot long, two-inch inner diameter Macro-Core[®] soil sampler equipped with a clean, disposable acetate liner. After the sampler was pushed through the target sampling interval, it was retrieved to the surface. The liner containing the sample was extruded from the sampler, the liner was cut open and the sample was cut into sections with a stainless steel spatula.

Soil collected from direct-push sampler borings (and borings advanced with hollow-stem auger and rotasonic methods) was placed into glass sample containers provided by the chemical analytical laboratory. The glassware was filled completely to minimize headspace, sealed tightly to avoid loss of VOCs, and placed on ice immediately. Sample containers were filled in a predetermined order based on the target analyte of each container. The sampling order was as follows:

- VOCs
- Indicator parameters
- SVOCs and pesticides
- pH
- Metals.

Soil samples collected during April 1997 were collected at a depth of 12 feet. In borings that extended beyond 12 feet bgs, soil samples were collected for chemical analysis at approximately 10-foot intervals. If field observations suggested the potential presence of COPCs, the sample was collected from a shallower depth within that 10-foot interval. If there was insufficient sample recovery in a target sampling interval, the sample was collected from

the next deeper sampling interval. Sample identifications were applied using the sample collection location and the depth interval that was sampled. For example, the sample collected at BSS4 from 10 to 12 feet bgs was identified as BSS4-12. Some sample identifications also include the depth of the top of the sampled interval. The borings were sealed with Type IA Portland neat cement.

6.2.2 Hollow-Stem Auger Drilling

Soil borings advanced with hollow-stem auger drilling methods were drilled by J&R Drilling Services, Inc. of Grimes, Iowa, using 4.5-inch inner diameter augers on a CME 75 drill rig. The borings were continuously sampled using a five-foot long, 3-inch diameter split barrel sampler. The sampler was advanced ahead of the lead auger flight into undisturbed material at the bottom of the boring.

Continuous soil samples were collected for description and chemical analysis. Total depth of the soil borings was determined based on the concentrations of the indicator parameters or the presence of saturated conditions. Soil borings BSS4 and BSS8 were terminated at 20 feet bgs because no indicator parameters were detected. BSS18, BSS21, BSS26, BSS32, and BSS33 were drilled to the depth at which groundwater was encountered, in accordance with the Work Plan, because indicator parameters were detected to this depth. Samples intended for chemical analysis were collected at approximately 10-foot intervals or where COPC impacts were apparent.

Monitoring wells MW1I, MW2I, MW3I, and MW4I were drilled to approximately 90 feet bgs in accordance with the Work Plan Addendum. Samples were collected for chemical analysis at MW1I through MW4I at approximate depths of 2 and 12 feet bgs to characterize surface and near surface concentrations of COPCs. Continuous core samples were collected at MW1I through MW4I from approximately 55 to the total depth of the soil borings to observe geologic contacts for monitoring well installation purposes. Continuous core samples were collected at PZ1, PZ2, and PZ3 from the ground surface to the bottom of the boreholes (107, 48.5, and 72 feet bgs, respectively) to evaluate stratigraphy in the Spring Lake Park area.

The split barrel sampler was advanced with the hollow stem augers. After the auger stem was advanced, the split barrel sampler was retrieved from the borehole. The split barrel sampler was opened and the soil core was removed. The soil core was cut into sections with a stainless-steel spatula and placed in laboratory-provided glassware.

Undisturbed soil samples were collected from each of the hydrostratigraphic units identified at the Facility for hydrologic testing. Repeated attempts were made to collect soil samples for hydrologic testing with Shelby tubes. Sufficient sample recovery was not achieved using this method so samples for hydrologic testing were collected using the split barrel sampler. Soil core samples were double-wrapped in saran wrap and aluminum foil. Samples for particle size analysis were placed in sealable plastic baggies. The samples were shipped to Daniel B. Stephens and Associates, Albuquerque, New Mexico for hydrologic testing.

Soil borings were sealed with a grout mixture of Portland cement and bentonite. Grout was pumped into the boreholes through a tremie pipe after the augers were pulled. The amount of cement, bentonite, and water used to seal each boring was recorded in the field logbook or on daily field logs.

6.2.3 Rotasonic Drilling

Rotasonic drilling methods were used for a number of deeper soil borings and well installations. This drilling method was selected for the following reasons: 1) to drill to depths greater than those attainable with a hollow-stem auger rig; 2) to minimize the volume of soil cuttings; and 3) to maximize sample recovery from the water-bearing sand unit encountered at the site below 70 feet bgs.

Alliance Environmental, Inc. of Marietta, Ohio operated the rotasonic drill rig. Continuous soil samples were collected with a 4-inch diameter, 10-foot long sample barrel. The sample barrel was advanced in ten-foot lengths and then over-ridden with 6-inch diameter casing. Potable water from the adjacent VW&R Facility was used to prevent soil from entering the borehole between the sample barrel and the casing.

6.2.4 Soil Sample Descriptions

Soil samples collected from the soil borings were classified using the Unified Soil Classification System (USCS) as described in American Society of Testing and Materials (ASTM) D2488. The following information was recorded on boring logs:

- USCS Classification
- Color using Munsell Soil Color Charts
- Moisture
- Consistency

- Structure
- Dry Strength
- Plasticity
- Reactivity to hydrochloric acid.

Boring logs are presented in Appendix B. Boring logs were prepared at an approximate vertical scale of two feet per inch. Also presented in Appendix B is a cross section containing logs for the test borings drilled by the Nebraska Department of Roads in July 1978 beneath the F Street viaduct (Nebraska Department of Roads, 1980).

6.3 SURVEYING

Each drilling location was marked at the time the location was sampled. The elevations of drilling locations were surveyed relative to the National Geodetic Vertical Datum (NGVD) within 0.01 feet. The locations were surveyed within 0.1 feet horizontally relative to a coordinate system established for the adjacent VW&R Facility. The survey was conducted by Ehrhart Griffin & Associates of Omaha, Nebraska. Table 5 presents survey data including the ground surface elevation and the northing and easting coordinates for the soil borings.

6.4 SOIL SAMPLE ANALYSIS

Soil samples were analyzed for indicator parameters, COPCs, hydrologic parameters and pH. The chemical analytical program is summarized in Table 6. The hydrologic testing program is summarized in Table 7. Analyses for indicator parameters and soil pH were conducted at the Facility. Samples were sent to off-site laboratories for analysis for COPCs and for hydrologic testing. Methodologies used for soil sample analysis are described in the following sections. The chemical analytical data are presented and discussed in Section 7.2.

6.4.1 On-Site Chemical Analysis

Chemical analyses were conducted for indicator parameters by Matrix Technologies, Inc., at the Facility while sampling was ongoing. Eighty-two soil samples were analyzed on-site using a mobile laboratory equipped with a gas chromatograph. The samples were analyzed for the indicator parameters in accordance with U.S.EPA Method 8010/8020 modified. Samples were concentrated with an OI-Analytical Model 4560 purge and trap sample concentrator. The purge and trap sample concentrator was directly connected to a Hewlett Packard 5890 Series II gas chromatograph. The samples were analyzed with a photoionization detector (PID) and a halogen-specific detector (XSD) in series.

The following laboratory quality assurance/quality control measures were conducted to ensure the validity of the analytical results:

- A five-point calibration curve for the method target compounds was established
- A prepared standard was run to verify the calibration curve
- A reagent water blank was run to assure the entire analytical system was free of interferences prior to sample analysis
- A surrogate standard (4-bromofluorobenzene) was run with each sample to monitor retention time accuracy and concentration efficiency
- A matrix spike and matrix spike duplicate were run to confirm precision and accuracy of the analytical system and to identify possible matrix effects.

Soil pH was measured on site using an Oakton soil pH test kit. Samples for pH analysis were collected at 10-foot intervals beginning at 20 feet bgs from borings BSS4, BSS8, BSS18, BSS21, BSS26, BSS32 and BSS33. The soil samples were placed in plastic baggies and stored on ice until analysis. Soil pH was measured within 24 hours after exposure of the soil sample to the atmosphere.

To measure soil pH, the soil sample was placed in a plastic jar with distilled water to form a soil slurry. The soil slurry was mixed and set aside 10 minutes to dissolve the salts in the soil. Soil pH was measured by dipping the Oakton pH Testr[®] into the solution. Following the completion of the test, the pH was recorded to the nearest 0.1 standard pH unit.

The measurements were performed and reactants were stored in accordance with the test kit manufacturer's instructions. Reaction powder and solutions were within their expiration dates. The pH test kit is accurate to ± 0.3 pH or better, according to Oakton. One duplicate sample measurement was performed for every 20 samples.

6.4.2 Off-Site Chemical Analysis of Soil

Soil chemical analytical methods are summarized in Table 8. Laboratory analyses were performed by Quanterra Analytical Services (Quanterra) and Columbia Analytical Services (CAS). Samples arrived at the laboratories in good condition. The temperatures of the sample coolers upon receipt at the laboratories were at the laboratory standard of $4 \pm 2^\circ\text{C}$. Dilutions were needed at times to avoid saturation of the detector, to achieve linearity for a specific target compound, or to reduce matrix interference. Where dilutions were used, reporting limits were adjusted upward proportionately. All sample results are reported on a "dry weight" basis.

Each laboratory analytical report included a cover letter, sample description information, sample analysis results sheets, a QC LOT assignment report, a duplicate control sample report, a laboratory control sample report, a matrix spike/matrix spike duplicate report, a single control sample report, and a method blank report.

6.4.3 Quality Assurance/Quality Control

Quality assurance/quality control (QA/QC) samples were collected in accordance with the work plan and work plan addenda. QA/QC samples included duplicates, field blanks, equipment blanks, matrix spike/matrix spike duplicates, and performance evaluation samples. One duplicate soil sample was collected for every 20 investigative soil samples. Field blanks consisted of analyzing samples of the water used for decontamination purposes. Equipment blanks were collected from rinsate that was passed over decontaminated soil sampling equipment. One performance evaluation sample, B-PE1, provided to Geomatrix by the U.S.EPA was submitted to CAS for metals analysis. In addition, Tetra Tech EM, Inc., personnel took split samples of four soil samples for the U.S. EPA. Table 9 provides a summary of the QA/QC samples related to soil including collection date, type of QA/QC sample, the sample matrix, analyses, and the corresponding investigative sample identification number. Laboratory analytical and QA/QC measures were in accordance with the Data Collection Quality Assurance Plan (DCQAP) included in the RFI Work Plan.

6.4.4 Hydrologic Testing

Hydrologic samples were sent to the Hydrologic Testing Laboratory at Daniel B. Stephens & Associates, Inc., in Albuquerque, New Mexico. All samples were received in good condition and in ample quantities to perform all testing procedures requested. Each sample was submitted in two portions, a bag labeled "TOC/CEC testing" and a core for hydraulic properties testing. Hydrologic testing methods are included in Table 3. Table 7 summarizes the hydrologic tests conducted during the RFI. Test results are presented and discussed in Section 7.1.

6.5 GROUNDWATER SAMPLING AND WATER LEVEL MEASUREMENT

Groundwater data collected during the RFI included measuring water levels, collecting groundwater samples for chemical analyses, and analyzing the groundwater samples for COPCs and parameters indicative of the capacity of the water-bearing unit to attenuate the migration of COCs. Monitoring wells and piezometers were installed for this purpose and groundwater samples were collected from temporary well screens installed in soil borings.

6.5.1 Monitoring Well and Piezometer Installation

Five monitoring wells were installed October 14 through 29, 1997, by J&R Drilling Services, under the oversight of a Geomatrix site geologist. Four of the wells, MW1I, MW2I, MW3I and MW4I, were screened near the top of the uppermost continuous water-bearing unit that underlies the Facility. Monitoring well MW4S, installed as a pair to monitoring well MW4I, was screened in a discontinuous water-bearing unit that is the shallowest water-bearing unit identified underlying the Facility.

Three monitoring wells, MW5I, MW6I and MW7I, were installed during June and July 1998, by Alliance Environmental, Inc., under the oversight of a Geomatrix site geologist. These wells were installed in the uppermost continuous water-bearing unit at approximately the same elevation as previously installed monitoring wells MW1I, MW2I, MW3I, and MW4I. Monitoring well MW6I was installed off site and upgradient of the Facility, monitoring well MW7I was installed off site and downgradient of the Facility, and Monitoring well MW5I was installed on site and sidegradient of the MW4S/MW4I well pair. The location and depth at which MW7I was installed was based on the results of groundwater sampling and analysis for COPCs in soil borings.

Monitoring well MW8I was installed by Alliance Environmental, Inc., under the oversight of a Geomatrix site geologist in March 1999. This well was located off site and downgradient of MW3I and was constructed in the same manner as MW7I. Also in March 1999, three temporary piezometers (PZ1, PZ2, and PZ3) were installed approximately one mile east of the site near Spring Lake Park. These temporary piezometers were installed in the uppermost water bearing unit by J & R Drilling Services under the oversight of a Geomatrix site geologist.

All monitoring wells were constructed with 2-inch diameter, flush threaded, stainless steel casings and well screens. All of the well screens were ten feet long, continuous wrapped screens with 0.010-inch slots (10-slot). Monitoring well construction details are summarized in Table 10. The hollow-stem augers or override casings were left in place while the well materials were constructed. The monitoring wells were lowered down to target depths and the filter pack was gravity fed through the hollow-stem augers or override casings to approximately two feet above the top of the well screen. As the filter pack was emplaced, the augers or override casings were lifted. Measured amounts of potable water were added to assist in creating a uniformly placed filter pack and prevent bridging. At MW8I, well centralizers were used because of the length of casing involved. The filter pack was gravity fed through the drill stem after an attempt at emplacing the filter pack sand through a tremie pipe was unsuccessful.

The tremie pipe could not be advanced to the depth of the well screen through the well centralizers. A one-foot thick (minimum) very fine sand seal was placed at the top of the filter pack. At least one foot of bentonite chips was emplaced above the very fine sand to form a bentonite seal above the filter pack, and the hollow-stem augers or override casings were removed. Above the bentonite seal, a bentonite cement grout was pressure grouted into the borehole annular space to the ground surface through a tremie pipe. Slots were cut in the bottom six feet of the tremie pipe to diffuse the flow of grout and prevent the displacement of the underlying bentonite seal. The well casing was protected at the ground surface with a lockable protective steel casing set in a concrete pad. Each well was then surrounded by bumper posts. As-built construction diagrams for each well are included on the well logs in Appendix B.

The piezometers were constructed inside the auger stem using 2-inch diameter PVC casing with 10-foot long, factory-slotted, PVC screens with 0.010-inch slots. A filter pack was emplaced to a depth approximately three feet above the top of the piezometer screen. A one-foot thick fine sand seal was placed above the filter pack. A bentonite seal was placed above the fine sand seal and the remainder of the borehole was pressure grouted with a bentonite grout. The piezometers were protected at the ground surface with lockable, steel protective casings. Piezometer construction details are summarized on Table 10.

The monitoring wells were developed after allowing a minimum of 24 hours for the cement to cure. The wells were developed by a bailing out the sediment that accumulated in the well screen and then pumping with a submersible pump. A surge block, in addition to the bailer and submersible pump, was used to develop monitoring wells MW2I and MW3I. Monitoring wells MW1I, MW4S, MW4I, MW5I, MW6I, MW7I, and MW8I were surged by moving the submersible pump through the water column during pumping. Monitoring wells were pumped until the groundwater temperature, specific conductivity, and pH stabilized to the criteria in the RFI Work Plan. MW8I was surged for approximately ten minutes and then bailed to remove solids. After solids were bailed, the well was pumped until temperature, specific conductivity, pH, and dissolved oxygen stabilized (within 10 percent between removed well volumes) and the pumped water was clear of turbidity. Within minutes of pump activation in monitoring wells MW3I and MW4S, the groundwater flow was depleted and the pump stopped discharging. After allowing time for groundwater to reenter the wells, the pump was set to the lowest pumping rate setting and reactivated. In both wells, there was insufficient groundwater recharge into the well screen to support pumping. Groundwater turbidity in MW3I and MW4S was high during development and therefore, groundwater parameters could not be accurately

measured. Development water was containerized in 55-gallon drums. Well development records are included in Appendix C. The piezometers were developed by surging the well screen with a submersible pump and removing approximately twice the amount of water used installing the piezometers.

The monitoring wells were registered with the State of Nebraska in accordance with State requirements. Ground surface and top of casing elevations of the monitoring wells and piezometers were surveyed relative to NGVD. The horizontal locations were measured from a local datum. The wells were surveyed within 0.01 feet vertically (relative to the NGVD) and 0.1 feet horizontally. Surveying was performed by Ehrhart Griffin & Associates of Omaha, Nebraska. Survey data are in Table 5.

After the piezometers were sampled, J&R Drilling Services, Inc. abandoned the piezometers in accordance with the State of Nebraska Well Code. Two of the piezometers, PZ2 and PZ3, were completely removed and the borehole sealed with bentonite. While attempting to remove PZ1, the casing sheared approximately 4 feet below the ground surface. The casing and screen remaining in the ground was sealed in place using bentonite.

6.5.2 Water Level Measurement

Water level data were collected in two ways during the RFI. When the soil borings were drilled in June 1997, the depth to water was unknown. Because a water-bearing zone was encountered, depth to water was measured in the drilled soil borings. These water level measurements provided a qualitative value for depth to water. Once monitoring wells were installed, the depth to water was measured quantitatively using a fixed datum point.

Depth to water at the time of drilling was monitored at soil borings BSS18, BSS26, BSS32, and BSS34. These soil borings were left open overnight with augers in place after the termination depth had been reached. Water levels in the soil borings were measured from ground surface. Water levels measured in the soil borings are shown graphically on the boring logs in Appendix B.

Water levels were measured in the monitoring wells and piezometers, relative to the surveyed measuring point, using a Solinst water level meter. The water level meter consists of a contact electrode suspended by an insulated electric cable embossed in graduations of a hundredth of a foot. Visual and audible signals (buzzer and light) showed a closed circuit and flow of current when the electrode touched the water surface. The measurement was repeated for verification

and noted on a water level record log. The electric sounder was rinsed with distilled water and wiped clean with a paper towel after each use. Care was taken not to let the cable or sounding device touch the ground around the borehole during monitoring.

6.5.3 Sample Collection

Groundwater samples were collected from monitoring wells, temporary piezometers and soil borings during the RFI.

Monitoring wells and temporary piezometers were sampled using a micropurging technique with a Grundfos Redi-Flo 2[®] submersible pump. The micropurging technique involved pumping a minimal amount of groundwater from the well prior to and during sampling, at a relatively low flow rate. Groundwater purging and sampling rates varied from approximately 0.1 gallons per minute (gpm) to 0.75 gpm. Groundwater samples were collected once a minimum of one well casing volume had been pumped from the well and the groundwater temperature, conductivity, and pH had stabilized within 10% between subsequent readings.

A groundwater sampling flow-through cell was used for monitoring groundwater flow parameters during sampling events which took place on and after July 14, 1998. In addition to groundwater temperature, conductivity, and pH, oxidation-reduction potential (ORP) and dissolved oxygen (DO) levels were monitored during micropurging. Groundwater stabilization parameters were recorded on well sampling records.

Monitoring well MW4S does not have the capacity to be sampled with a submersible pump due to the low volume of groundwater contained in the well and the low recharge rate to the well screen. Monitoring well MW4S was sampled with a 0.5-inch diameter, hand operated inertial pump manufactured by Waterra. Pumping rates between 0.1 and 0.06 gpm were maintained with this system without MW4S going dry. Groundwater samples were collected with after a minimum of one well casing volume had been purged and the groundwater stabilization criteria had been met.

Groundwater samples were collected in appropriate sample containers for analysis for in the following order: 1) VOCs, 2) SVOCs, 3) pesticides, 4) metals, 5) attenuation parameters. The sample containers were labeled, logged into appropriate field records, stored in iced coolers, and shipped to the analytical laboratory under chain-of-custody procedures.

A total of six groundwater samples were collected on vertical profiles in soil borings BSS51 and BSS52. Samples were collected at the top of the uppermost continuous water-bearing unit and at ten-foot intervals within this unit. Groundwater samples were collected from native materials by removing the soil sampling barrel and inserting a 3-foot long, temporary well screen to the desired sampling interval near the base of the override casing. The override casing was then pulled back three feet to expose the well screen and allow the native material to collapse against the screen. A packer was placed above the well screen to separate the screened interval from the water contained in the override casing. Groundwater was purged from the temporary screen at a low flow rate with a submersible pump. Groundwater temperature, pH, specific conductivity, ORP, and dissolved oxygen were monitored during purging. Once the groundwater parameters stabilized within 10%, a groundwater sample was collected in laboratory-supplied containers. The sample containers were labeled, logged into appropriate field records, stored in iced coolers and shipped to the analytical laboratory under chain-of-custody procedures.

6.6 GROUNDWATER SAMPLE ANALYSIS

Chemical analysis of groundwater samples was conducted for COPCs and natural attenuation parameters (U.S.EPA, 1997b) by CAS at their laboratory in Kelso, Washington. Midwest Laboratories, Inc. (Midwest) of Omaha, Nebraska analyzed the groundwater screening samples collected from off-site borings BSS51 and BSS52.

The samples arrived at the laboratories in good condition. The cooler temperatures upon receipt were at or cooler than the temperature preservation standard. Dilutions were needed at times to avoid saturation of the detector, to achieve linearity for a specific target compound, or to reduce matrix interference. Where dilutions were used, reporting limits were adjusted upward proportionately. Laboratory analytical data were delivered in both hard and electronic copies. Laboratory analytical reports issued by CAS included a cover letter, sample description information, sample analysis result sheets, a QC LOT assignment report, duplicate control sample report, laboratory control sample report, matrix spike/matrix duplicate spike report, single control sample report, and method blank report. Copies of the laboratory analytical reports are included in Appendix D.

The groundwater chemical analysis program is summarized in Table 11. This table lists the sample identification numbers, sampling dates, and the analytes. The methods used for groundwater chemical analysis are summarized in Table 12. The chemical analytical data are presented and discussed in Section 7.2.

Groundwater QA/QC samples were collected in accordance with the work plan and work plan addenda. Groundwater QA/QC samples included duplicates, a field blank, equipment blanks, a matrix spike/matrix spike duplicate, and performance evaluation samples. One duplicate groundwater sample was collected every sampling event. Field blanks consisted of analyzing samples of the water used for decontamination purposes. Equipment blanks were collected by pumping distilled water through the pump and sampling tubing in November 1997 and thereafter by passing distilled water over the pump and into sample containers. Performance samples provided to Geomatrix by the U.S.EPA in 1997 were submitted to CAS for VOC and metals analysis. In addition, Tetra Tech EM, Inc., personnel took split groundwater samples for VOC and metals analysis. Table 13 provides a summary of the QA/QC samples related to groundwater including collection date, type of QA/QC sample, the sample matrix, analyses, and the corresponding investigative sample identification number. Laboratory analytical and QA/QC measures were in accordance with the DCQAP included in the RFI Work Plan.

6.7 SURFACE WATER CONDITIONS

On-site observations of surface water conditions at the Facility were made during each phase of investigation in April, June, and October 1997 and January 1998. Surface water conditions are discussed in Section 7.1.3.

6.8 CLIMATIC CONDITIONS

Climatic data was obtained for the weather station at Eppley Field, Omaha's main airport located approximately 9 miles northeast of the Facility. The data, which includes temperature, precipitation, wind, atmospheric pressure, and relative humidity, were obtained through the National Climate Data Center (NCDC) in Asheville, North Carolina in hard copy or from their on-line database. Information on the development of inversions was obtained from the National Weather Service office in Valley, Nebraska. An isopleth map of pan evaporation was obtained from the High Plains Climate Center in Lincoln, Nebraska. Additional climatic observations were obtained from the soil survey publication for Douglas County (U.S.DA, 1975).

6.9 RISK CHARACTERIZATION

The methodologies employed to characterize the potential risk to human health and the environment are described in the following sections.

6.9.1 Soil

Risk characterization of constituents detected in soil included refining the initial list of COPCs and identifying areas of the site potentially requiring corrective action to reduce human health risk to acceptable levels.

6.9.1.1 Evaluation of COPCs

The initial list of COPCs was refined based on data collected during the RFI, native concentrations (for metals) and established regulatory risk-based criteria for protection of human health. The maximum detected concentration in soil for non-metal COPCs were compared to the U.S.EPA, Region III RBCs for exposure to residential soils. The most-recently updated risk-based concentration table was used as the reference (U.S.EPA, 1998a). In addition, maximum detected concentrations were also compared to soil screening levels (SSLs) for transfer from soil to air (SSLair), published in the U.S.EPA Soil Screening Guidance (U.S.EPA, 1996). Metals concentrations in soil were compared to the range of native concentrations reported in the published literature (Shacklette and Boerngen, 1984). Metals were not considered a COPC if the maximum concentration did not exceed the range of native concentrations. It should be noted that SSLs have not been developed for some of the chemicals detected at the Facility; SSLs for these chemicals were calculated based on the methodology provided in the U.S.EPA Soil Screening Guidance. These calculations are documented in Appendix E. SSLair values represent soil concentrations protective of air based on default assumptions regarding the potential volatilization of a chemical from soil to air. The U.S.EPA does not develop SSLair values for non-volatile compounds because inhalation of particulates (i.e., dust) is not considered to be a significant pathway for exposure for these chemicals.

6.9.1.2 Identification of Areas Potentially Requiring Corrective Action

The comparison of Facility data to the risk-based criteria was sufficient to conclude that some corrective action will be necessary for soil. Therefore, no baseline risk assessment was conducted. Instead, the areas of soil that may pose an unacceptable risk to potential receptors were identified by the following process: 1) identifying potential receptors and exposure pathways, 2) estimating exposure point concentrations based on current conditions, 3) identifying geographic areas that contribute most significantly to the overall risk, and 4) estimating the residual risk (i.e., the risk that would remain) after areas of concern were hypothetically contained, removed, or otherwise addressed by corrective action. These steps were repeated in an iterative fashion. The area potentially requiring corrective action was

increased in size until the residual risk was reduced to a level equal to or below 1×10^{-5} for carcinogenic chemicals (i.e., as an aggregate; risks for individual constituents did not exceed 3×10^{-6}) and a hazard index of 1 for non-carcinogenic chemicals. Default input parameters prescribed by U.S.EPA for the potential receptors, accounting for potential exposure pathways, were used to identify areas that may require corrective action. Potential receptors were identified as future long-term industrial workers and future short-term construction/utility workers.

6.9.2 Groundwater

Environmental Database Resources, Inc. was used to conduct a search for water wells within the Facility area. This information supplemented the data in the DCC (Geraghty & Miller, 1996). The City of Omaha was contacted to obtain information regarding ordinances covering groundwater development in the area.

Hydrostratigraphic and topographic data were used to evaluate groundwater migration pathways. Physical and geochemical data were used to evaluate the fate and transport of COCs. The calculation of groundwater fate and transport parameters is presented in Table 14.

6.9.3 Ecological Risk

Ecological data were obtained from the Nebraska Game and Parks Commission.

7.0 RESULTS

Findings regarding the environmental setting of the Facility, chemical characterization of areas of concern, and the identification of potential receptors are presented in the following sections.

7.1 ENVIRONMENTAL SETTING

The environmental setting of the Facility and surrounding area is described in the following sections in terms of hydrogeology, groundwater, surface water, and climatic conditions.

7.1.1 Hydrogeology

The Facility is located on a loess-mantled upland till surface, at an elevation of approximately 1,130 feet above NGVD. As the Facility is in an urban area, pavement or fill is commonly present at the ground surface. Where fill is not present, native soil is the deep, well drained, nearly level to very steep silt loam of the Monoma-Ida association (U.S.DA, 1975). Geologic units encountered with increasing depth include loess deposits of Wisconsinan (Bignell and Peoria Loesses) and Illinoian (Loveland Loess) age, and till and outwash deposited by multiple

glaciations during the Quaternary (Miller, 1964). The Quaternary deposits are underlain by bedrock approximately 200 feet bgs (Burchett, et al., 1975). The bedrock consists of Pennsylvanian age limestones and shales of the Kansas City and Pleasanton Groups (Miller, 1964). The conceptual hydrostratigraphy of the region is summarized in Table 15 and illustrated in cross-section on Figure 5.

The scope of the RFI included characterizing the uppermost Quaternary deposits, including the loess and uppermost glacial deposits. These geologic units are illustrated in a cross section of the Facility on Figure 6. The cross section location is illustrated on Figure 7. Hydrologic data for the loess and uppermost glacial deposits, including moisture content, bulk density, porosity, hydraulic conductivity (saturated and unsaturated), particle size, cation exchange capacity, and soil organic content, are summarized in Table 16. The test results from the hydrology laboratory (D.B. Stephens & Associates) are presented in Appendix D.

The loess is a yellowish brown to brown clayey silt and extends to as much as 65 feet bgs at the Facility (Figure 6). Median particle diameter (d_{50}) of six samples collected from the loess unit ranged from 0.013 to 0.024 millimeters (mm), illustrating the fine-grained nature of the material. The loess ranges from soft to firm, low to moderately plastic, and is mostly homogeneous with some mottling and fractures. Test results indicate the hydraulic conductivity of the material is relatively low with a saturated hydraulic conductivity (K_{sat}) of 2.9×10^{-7} centimeters per second (cm/sec) and an unsaturated hydraulic conductivity (K_{unsat}) of 2.6×10^{-9} cm/sec on average. The loess samples contained substantially more organic carbon than did samples of the underlying glacial deposits, averaging 1,032 milligrams per kilogram (mg/kg) total organic carbon (TOC). Overall, the organic carbon content of samples of the deposits underlying the Facility was relatively low (typically much less than 1 percent).

Four hydrostratigraphic units were identified within the glacial deposits underlying the loess at the Facility. In order of increasing depth, they are as follows:

- Shallow (S) Stratified Unit
- Shallow (S) Till Unit
- Intermediate (I) Sand Unit
- Intermediate (I) Till Unit

Beneath the loess is a heterogeneous unit containing stratified deposits ranging from sandy silt to gravel, referred to as the S Stratified Unit in this report. This unit tends generally to coarsen downward. A gravel or sand lag deposit was observed at the base of the unit at some, but not all locations. Median particle diameter for five samples collected from the S Stratified Unit ranged from 0.015 to 0.054 mm, which is similar to the loess. However, a sixth sample from this unit contained more sand and had a median particle diameter of 0.47. This illustrates the variability in grain size in samples from this unit compared to the samples from the loess. The unit is interpreted to have been deposited in a fluvial environment and confined to buried valleys eroded into the underlying S Till, similar to deposits described in the published literature (Miller, 1964). The S Stratified Unit was observed to be approximately 15 feet thick at MW1I, but absent at MW7I and MW8I.

Monitoring well MW4S is screened in the S Stratified Unit. The unit yields groundwater slowly at MW4S, where the unit was observed to be relatively fine-grained. The geometric mean of saturated hydraulic conductivity of two samples collected from the S Stratified Unit were approximately one order of magnitude lower than that of the loess. The unsaturated hydraulic conductivity is substantially lower than saturated hydraulic conductivity, with the geometric mean of K values of 2.7×10^{-11} cm/sec and 2.2×10^{-8} cm/sec, respectively. The sand and gravel lag deposit was too thin to collect a sample for hydrologic tests but based on observed texture, the hydraulic conductivity of this zone is likely to be higher than the calculated mean for the unit.

The S Stratified Unit is underlain by a dark gray to black, sandy lean clay to lean clay textured till that contains a heterogeneous mixture of pebbles. This unit (S Till) is relatively consistent in appearance, is relatively thin and appears likely to be discontinuous across the Facility. The unit thickens to the east and south (Figure 6). Samples of the till were finer grained than the other deposits that were encountered, with a median particle diameter that ranges from 0.0092 to 0.045 mm. As with the S Stratified Unit, a relatively large difference between saturated and unsaturated hydraulic conductivity was observed in samples from the till unit. The geometric mean of K values is 1.3×10^{-7} cm/sec and 9.5×10^{-12} cm/sec, respectively.

A stratified sand unit referred to as the I Sand Unit underlies the S Till. The I Sand Unit is comprised of yellowish to grayish brown medium to coarse grained, poorly graded sand interpreted to be glacial outwash. This is the uppermost continuous water bearing unit at the Facility and the monitoring wells with "I" suffixes are screened in this unit. The I Sand Unit was observed to be approximately 25 feet thick, fully saturated, and hydraulically confined.

Median particle diameter for seven samples collected from the sand unit ranged from 0.26 to 0.62 mm (medium sand). Effective particle size data (d_{10}) were used to calculate hydraulic conductivity by Hazen's Method. The geometric mean of the eight calculated hydraulic conductivity values is 3.4×10^{-2} cm/sec. Porosity of the unit is estimated to be 35 percent.

The characteristics of the loess, I Sand Unit, and I Till Unit described at the three piezometer boreholes drilled approximately one mile east of the Facility are similar to and appear to correlate with units observed at and near the Facility. Saturated conditions were encountered in the I Sand Unit at each of the three piezometers. The thickness of the sand unit varied from 15 feet at PZ2 to 53 feet at PZ1. The upper 21 feet of the sand unit at PZ1 was unsaturated and generally finer grained than at the Facility. Description of the units encountered during drilling and construction logs of piezometers PZ1, PZ2, and PZ3 are included in Appendix B. The S Stratified Unit and S Till Unit were not observed at the piezometers. This is consistent with Miller (1964) in that they may be eroded away in some places. The hydrostratigraphy observed at the Facility and at the piezometers correlates with that observed by Miller (1964) at an outcrop mapped at an elevation between 1,030 and 1,050 feet NGVD at the location south of Spring Lake Park illustrated on Figure 8. The ravine at Spring Lake Park completely dissects the sand unit, as the sand was not observed in geotechnical borings drilled at the base of the ravine (Huntingdon/Nebraska Testing Corporation, 1993).

7.1.2 Groundwater

Saturated conditions were encountered in the S Stratified Unit and the I Sand Unit. The regional groundwater flow pattern is from the uplands toward the east and southeast, and ultimately the Missouri River (Burchett and Carlson, 1966). Recharge to the I Sand Unit is primarily from areas of higher elevation and outcrop areas west of the Facility. Groundwater within the I Sand Unit primarily discharges at outcrops along the west side of the Missouri River valley, approximately $1\frac{1}{2}$ miles east of the Facility (University of Nebraska, 1986). The groundwater flow map illustrated on Figure 8 is based on water level measurements made at the Facility and at piezometer PZ3, and on published regional groundwater flow maps (Burchett and Carlson, 1966). The elevation of the base of the mapped sand unit south of Spring Lake Park is at 1,030 feet NGVD, at least 10 feet higher than the water levels measured in the temporary piezometers. Unless the sand is not saturated at the mapped location, this would give a water level of at least 1,030 at this location, which further supports the groundwater flow interpretation illustrated on Figure 8.

Water levels measured at MW4S from November 1997 through March 1999 show a water table elevation of approximately 1,070 feet above NGVD, or approximately 70 feet bgs. The groundwater elevation and groundwater flow direction within the I Sand Unit at and near the Facility is illustrated on Figure 9, based on water levels measured on March 24, 1999. The horizontal hydraulic gradient is approximately 0.002. This flow direction has been consistently observed in monthly water level measurements since data collection began in November 1997 and matches the published literature on regional groundwater flow (Burchett and Carlson, 1966). The water level in the I Sand Unit has fluctuated over a range of approximately 5.5 feet during the period of observation. The water level in the S Stratified Unit has consistently been approximately 1.5 to 2 feet higher than that in the underlying I Sand Unit, indicating the presence of a downward hydraulic potential. The water levels are plotted as a function of time on Figure 10. Water levels measured in monitoring wells and piezometers are summarized in Table 17. Water level records are presented in Appendix C. Using the mean hydraulic conductivity estimate of 3.4×10^{-2} cm/sec for the sand unit, an estimated porosity of 35 percent, and a horizontal hydraulic gradient of 0.002, a horizontal groundwater velocity of 0.6 feet per day, or approximately 200 feet per year, is estimated for the I Sand Unit.

Based on the regional topography and hydrostratigraphy, groundwater within the I Sand Unit likely discharges to the surface where the unit is exposed by erosion, east-southeast of the Facility. Groundwater elevations at the piezometers in the Spring Lake Park area support the regional groundwater flow pattern toward the southeast (Figure 8). A ravine in the Spring Lake Park area, approximately 1 mile from the Facility, is the closest potential discharge point east-southeast of the Facility (Figure 8). Geotechnical borings drilled near Spring Lake Park Boulevard and I Street, at the base of the ravine, encountered several feet of fill overlying a till unit (Huntingdon/Nebraska Testing Corporation, 1993), indicating the I Sand Unit has been completely eroded away within the ravine. The bottom of the ravine has been filled in large areas of the Spring Lake Park and groundwater may discharge along with surface water runoff to a storm sewer placed within the fill. The storm sewer ultimately discharges to the Missouri River approximately a half mile away.

7.1.3 Surface Water

Surface water bodies in the area are illustrated on Figure 11; none are located within one mile of the Facility. Surface drainage (e.g., from rainfall or melting snow) from the Facility area follows the trend of the valley south toward Mud Creek, which is three miles south of the Facility.

Most of the ground surface at the Facility is covered with gravel underlain by the Permalon liner. Concrete foundations are present at ground surface in some locations. Surface runoff over most of the Facility is prevented from infiltrating into the subsurface by the presence of the gravel and Permalon liner and the foundations. Surface cover is illustrated on Figure 12. The runoff collected in the gravel cover above the liner flows to storm sewer inlets located on either side of the road on the Facility. A culvert underneath G Street directs runoff from the southern part of the Facility to a drainageway parallel to the railroad tracks southwest of the Facility (Figure 12).

Prior to installation of the gravel and Permalon cap in 1991, surface drainage at the Facility was overland to the west toward the former railroad siding. The railroad siding has been removed and there is now an unpaved road at the former railroad siding (Figure 12). The railroad siding was slightly elevated above the surrounding terrain, creating a berm that would have redirected surface drainage southward, parallel to the railroad tracks. Runoff from the Facility would have had to flow south nearly three miles to reach Mud Creek.

7.1.4 Climate

The climate in Omaha is characterized by warm summers, cold winters, and moderate rainfall. Climatic data, summarized by month, are presented in Table 18. The average annual temperature is 50.6° F. The temperature was as high as 114° F in 1936 and as low as -32° F in 1884 (NCDC, 1997). Temperature is at or below 32° F an average of 141 days annually (NCDC, 1997). The average date of the first fall freeze is October 10; the average date of the last spring freeze is April 24 (NCDC, 1997). If moisture is sufficient, frost penetrates to depths of 2 to 3.5 feet below ground surface (U.S.DA, 1975).

The average annual precipitation is 29.86 inches. The most rain received in a 24-hour period is 7.03 inches. Approximately $\frac{3}{4}$ of the annual precipitation falls as rain from April to September. The average annual snowfall is approximately 29.9 inches (NCDC, 1997). Snow covers the ground for an average of 46 days in the winter (U.S.DA, 1975).

The average annual wind speed is 10.5 miles per hour. The prevailing direction of the wind is from the south-southeast from May to September and from the north-northwest during the rest of the year. The fastest wind speed on record is 109 miles per hour (U.S.DA, 1975).

Relative humidity is typically higher in the morning than in the evening. Annually, it averages 82% in the morning and 59% in the afternoon (NCDC, 1997). Mean annual pan evaporation is

approximately 58 inches (U.S. Department of Commerce, 1983). Approximately 77% of the total evaporation occurs from May through October. Atmospheric pressure averages 980.6 milliBars (mB) annually, with monthly averages ranging from 977.7 mB in June to 983.8 mB in February (Dutcher, 1997).

Daily and seasonal temperature inversions occur in the Omaha area (Byrd, 1997). The daily temperature inversions occur at night and are weak. These inversions typically break up in the morning as the sun rises. The seasonal temperature inversions typically occur during the winter months. These inversions are stronger and their depth varies with the season. The strong winds in the Omaha area tend to break up these inversions so entrapment of air is minimal.

7.2 CHEMICAL ANALYSES

The chemical analytical results for soil and groundwater are summarized in this section. Results for soil from the Phase I sampling (HLA, 1991) are presented along with the RFI data to help characterize the soil chemical conditions. Results for groundwater include analyses for COPCs and for attenuation parameters. The chemical data reports from Quanterra, CAS, Matrix, and Midwest are presented in Appendix D. Chain-of-custody records that accompanied the samples during delivery to the analytical laboratory are also provided in Appendix D, appended to the chemical data reports.

7.2.1 Soil

VOCs, SVOCs, pesticides, and metals were detected in soil. No PCBs or dioxins were detected. The detected concentrations of COPCs in soil are tabulated in Appendix F.

TCE and PCE were the VOCs most often detected in soil. The highest VOC concentrations were detected in the northwestern part of the Facility. VOCs were not detected or were detected at relatively low concentrations on the eastern side of the Facility (i.e., east of the road that bisects the Facility).

The two highest TCE concentrations were 250 mg/kg at BP13 (collected during the Phase I Investigation) at a depth of 4 to 5 feet and 150 mg/kg at BSS26 at a depth of 12 feet bgs. The highest PCE concentration was 67 mg/kg at BSS32 at a depth of 9 feet bgs. Samples collected at the ground surface were observed to have lower VOC concentrations than samples collected from the subsurface or from below paved areas. This pattern is likely the result of a loss of mass through volatilization from soil to air that would have occurred primarily prior to placement of the liner. Within the subsurface, the frequency and magnitude of VOC

concentrations were observed to decrease with increasing depth but several VOCs, including acetone, chloroform, toluene, TCE, and xylenes, were detected at depths greater than 50 feet bgs. The areal distribution of TCE in soil is illustrated on Figure 13 and in cross section on Figure 14.

SVOCs were detected far less frequently than VOCs, and at far lower concentrations. In addition, SVOCs were limited to surface samples. The SVOC detected at the highest concentration was pentachlorophenol. However, pentachlorophenol was detected in only one sample, at ground surface at BP8.

Metals were frequently detected in soil at the Facility. The detected concentrations are summarized in Table 19 including the range of values and the mean for each metal. Information in Table 19 is used to compare data from the Facility to data from the adjacent VW&R facility (Geomatrix, 1998b) and to native soil from a study by the U.S.GS (Shacklette and Boerngen, 1984). The range of values for metals throughout the Facility suggest typical variation within soil and do not indicate the presence of "hot spots" of large metal concentrations, with the exception of lead and iron. The results for lead and iron in Appendix F show the outlier is the surface sample at BP-5. Metals results for the Facility are comparable to those from the adjacent VW&R facility (Geomatrix, 1998b). When compared to published native soil concentrations, just one metal result exceeded the range observed under natural conditions. This result was for lead, at 829 mg/kg in the surface soil sample collected at BP-5. All other lead results were within the range of native soil concentrations. The result for iron at BP-5 is within the range for native soils.

The highest pesticide concentrations were detected near the southwest corner of Former Warehouse No. 1, in the area of BP6, BP7 and BP8. The frequency and magnitude of pesticide concentrations were observed to be highest in soil near the surface (less than 2 feet bgs) and to decline by orders of magnitude with increasing depth. Pesticides were not detected or were detected at only trace concentrations at depths greater than 12 feet bgs. The most frequently detected pesticides were aldrin and dieldrin. The maximum aldrin concentrations were 240 mg/kg at BP6 and 230 mg/kg at BP7 (collected during the 1990 Phase I Investigation) both at a depth of 0.5 to 1.5 feet. The maximum dieldrin concentrations were 48 mg/kg at BP8 and 42 mg/kg at BP6, both in surface samples. Aldrin naturally degrades to dieldrin over time. Dieldrin was selected to illustrate the distribution of pesticides in soil because it was the most widespread. The detected concentrations of dieldrin are illustrated in map view on Figure 15 and in cross section on Figure 16.

7.2.2 Groundwater

Groundwater results are presented in two sections. First, the results for COPCs are presented. Presented second are results for groundwater parameters used to evaluate the capacity of the aquifer to attenuate the migration of COCs.

7.2.2.1 COPCs

VOCs were detected in groundwater at and downgradient of the Facility. Not all VOCs detected in soil at concentrations above SSL_{gw} values were detected in groundwater. For example, acetone and toluene were detected in soil to the depth of the water table but were not detected in groundwater. Pesticides were not detected except at extremely low concentrations, and these results were not reproducible in subsequent sampling and analysis. The concentrations for detected COPCs in groundwater are tabulated in Appendix F.

Of several VOCs that were detected, TCE was detected at the highest concentration, an order of magnitude higher than other VOCs. Therefore, TCE results are described in detail as indicative of the size and distribution of the groundwater VOC plume. The VOC data are summarized in Table 20. TCE was detected at concentrations ranging between 19,000 and 24,000 micrograms per liter ($\mu\text{g/l}$) at MW4S. MW4S is located within or near likely source areas for TCE. Approximately 700 feet downgradient of MW4S, at MW7I, the TCE concentration has ranged between 1,200 and 1,900 $\mu\text{g/l}$. TCE concentrations at the Facility are illustrated on Figure 17. The vertical distribution of TCE within the I Sand Unit was illustrated by sampling on a vertical profile in soil borings BSS51 and BSS52 drilled near MW7I in July 1998. The TCE concentration was highest in a sample collected at 115 feet bgs, in the middle of the I Sand Unit. The concentration detected at this depth is comparable to subsequent results from MW7I. Trace concentrations of TCE were detected at depths of 105 and 125 feet, near the top and bottom, respectively, of the unit.

Groundwater chemical data, flow data and hydrostratigraphy were used to evaluate the migration pathway for TCE downgradient from MW4S and toward MW7I. The groundwater flowpath between MW4S and the I Sand Unit is likely to be complex, given the heterogeneity of the S Stratified Unit and the discontinuous nature of the intervening S Till Unit. TCE concentrations are much lower at MW4I than at MW4S. This suggests the groundwater flowpath is primarily horizontal within the S Stratified Unit at this location. TCE was detected at MW2I at concentrations that are relatively low (Table 20) when compared to results from MW7I, considering that MW2I is located approximately midway between MW4I and MW7I, along the apparent groundwater flowpath. Based on the distribution of TCE, the groundwater

flowpath from the S Stratified Unit down into the I Sand Unit appears to be east of MW4S. The center of the plume appears to bypass MW2I to the east as it migrates toward MW7I. In addition, TCE was detected at only trace concentrations at MW5I, located east of MW4S. This indicates the width of the part of the plume containing the highest concentrations (greater than 1,000 µg/l) may be less than 100 feet. TCE results from MW3I have fluctuated, suggesting the nearby presence of a source in that area. Downgradient of MW3I at MW8I, TCE results were relatively low at 11 µg/l. Because MW8I is sidegradient of MW7I this relatively low TCE concentration suggests a plume that is limited in width.

PCE, 1,1,1-trichloroethane (1,1,1-TCA), and carbon tetrachloride were also detected in groundwater, at concentrations of up to 1,600 µg/l, 1,200 µg/l, and 390 µg/l respectively. The distribution of PCE and 1,1,1-TCA was similar to that of TCE, in that the highest concentrations were detected at MW4S and declined significantly in the downgradient direction. The distribution of carbon tetrachloride was somewhat different in that the concentrations at MW4S were lower than at MW8I (Figure 18). This suggests that the source for carbon tetrachloride is likely near MW3I, which is consistent with former land use. Based on groundwater flow direction within the I Sand Unit, MW8I is directly downgradient of the southwestern part of the Facility (Figure 9).

Degradation products of TCE, PCE, 1,1,1-TCA, and carbon tetrachloride were detected at relatively high concentrations in groundwater at the Facility. The distribution of cis-1,2-dichloroethene (DCE) illustrates the distribution of these "daughter products" and is shown on Figure 19. The highest DCE concentrations were detected at MW4S, where it was detected at up to 1,400 µg/l. DCE concentrations at MW2I were also relatively high, ranging up to 1,100 µg/l, and concentrations at MW7I ranged up to 700 µg/l. The ratio between DCE and TCE at MW4S was approximately 6 percent, while at MW7I the ratio was over 50 percent. TCE has been dechlorinated to DCE along the groundwater flowpath. Vinyl chloride has not been detected at the Facility.

No COPCs were detected in the groundwater samples collected at piezometers PZ1, PZ2, and PZ3. The only VOC detection was dichlorofluoromethane, at 1.2 µg/l in PZ3.

Dichlorodifluoromethane is not considered to be a COPC and was not detected in any of the groundwater samples collected at the Facility. This compound is not associated with the Facility. No VOCs were detected in groundwater samples collected from PZ1 or PZ2.

7.2.2.2 Attenuation Parameters

The pattern of geochemical conditions and the large decrease in COC concentrations observed along the groundwater flow path downgradient of the source area provide strong evidence of natural attenuation based on the applicable U.S.EPA technical protocol (U.S.EPA, 1998b). Anaerobic conditions are established in the source area, and where anaerobic conditions exist there is strong evidence in the geochemical data for reductive dechlorination. The natural attenuation screening protocol using Facility data is summarized in Table 21. Under these geochemical conditions, TCE will be reductively dechlorinated in a sequence to DCE, vinyl chloride, ethene and carbon dioxide. Farther downgradient, where aerobic conditions are re-established, DCE and vinyl chloride will degrade to ethene and carbon dioxide.

The attenuation parameter concentrations, presented in Table 22, indicate that anaerobic conditions are present at some locations, such as the source area, within an overall aerobic environment. The presence of anaerobic conditions is indicated by low (i.e., below one milligram per liter) dissolved oxygen, and relatively high methane, relatively high dissolved iron, and relatively low nitrate concentrations. The presence of an overall aerobic environment is suggested by relatively high dissolved oxygen, relatively low dissolved iron, and relatively high nitrate concentrations at downgradient locations.

7.2.3 QA/QC for Soil Chemical Data

The chemical analytical results from the RFI were validated based on the result of the QA/QC procedures. Data collected during the Phase I Investigation had been previously validated (HLA, 1991). The QA/QC process included evaluating blanks, duplicates, holding times, completeness of the data reports, and surrogate and spike recoveries, and QA/QC issues noted by the laboratory and reported in the case narrative of the laboratory reports.

7.2.3.1 Blanks

No analytes were detected in the trip blanks. In equipment rinseate blanks, bis (2-ethylhexyl) phthalate (June 1997), and PCE (October 1997) were detected. In the field blanks, chloroform (June and October 1997), bromodichloromethane (June 1997), dibromochloromethane (June and October 1997), bis (2-ethylhexyl) phthalate (June 1997), and PCE (October 1997) were detected. The compounds bis (2-ethylhexyl) phthalate, bromodichloromethane, and dibromochloromethane were not detected in any of the investigative samples so no results were qualified with respect to these compounds. Chloroform and PCE results were not qualified where the investigative result exceeded five times the blank result.

Detected concentrations of common laboratory contaminants in laboratory method blanks were considered in validating the data. Methylene chloride, acetone, 2-butanone, and bis (2-ethylhexyl) phthalate were detected in laboratory blanks. Methylene chloride was not detected in any investigative samples corresponding to the affected method blanks so no results were qualified. 2-Butanone was detected in sample BSS32-20 at a concentration greater than ten times the concentration detected in the associated blank and therefore no data were coded as a result. Acetone concentrations in samples BSS21-21 and BSS21-12 were less than ten times the concentration of acetone detected in the associated blank so these results were coded "U" as not detected in accordance with U.S.EPA guidelines for validation of organics data. The compound bis (2-ethylhexyl) phthalate concentrations in samples B-EB1 and B-FB1 were less than ten times the concentration in the associated blank. These data were also qualified as non-detections (U).

7.2.3.2 Duplicates

No analytes were detected in both the investigative and duplicate soil samples collected from BSS33-21, BSS33-48. The relative percent difference (RPD) values calculated for metals between duplicates and investigative samples BSS32-40 and MW3-2.5 were less than 40, supporting the analytical results. The RPD values calculated for acetone in the duplicate samples ranged from 41.3 to 200. Based on the RPD values, detected concentrations of acetone in soil samples BSS39-2, MBSS21-12, and MBSS21-21 were coded with "J" as estimated values. Due to the difficulty of quantifying acetone, all of the acetone detections from on site analyses (MBSS21-63, MBSS26-17.5, MBSS26-30, MBSS26-40, MBSS26-50, MBSS32-49, MBSS32-59, MBSS37-30, and MBSS49-2) were coded "J" as estimated. RPD values calculated for metals and VOCs from MW3-2.5 were less than 40 (supporting the analytical results) so no data were qualified. The calculated RPD values for the indicator parameters from samples BSS21-63, BSS33-60, and BSS44-2 range from 3.2 to 42.9. Generally the RPD values were less than 40 for the analytes detected in the soil samples which supports the precision of the data. The disparate RPD values are likely caused by heterogeneous distribution of analytes with the soil matrix rather than analytical methodology.

7.2.3.3 Completeness

Chain of custody forms were cross-checked against laboratory reports for completeness. Soil sample BSS37-2 (October 1997) was inadvertently not analyzed for metals. Sample BSS37-10 was analyzed as a replacement.

7.2.3.4 Holding Times

Samples were extracted and/or prepared and analyzed within the appropriate holding times. VOC analysis of samples BSS39-2, BSS34-2, and MSD-BSS36-2 was initially performed within the recommended holding times; however, surrogate recoveries were slightly outside criteria. The samples were reanalyzed for VOCs outside the holding times. Detected concentrations from the re-analyses were coded "J" and non-detects coded "UJ".

7.2.3.5 Surrogate and Spike Recovery

One or more surrogates were out of the surrogate recovery range for the following VOC soil sample analyses due to matrix interference: BSS40-2, BSS34-2, BSS35-2, BSS41-2, BSS42-2, MW2-2, MW3-2.5 and BSSD5. All VOC data from the samples listed above were coded as estimated values, "J" for detects and "UJ" for non-detects. Two or more surrogates were out of range for the following SVOC soil sample analyses: BSS33-10, BSS33-28.5, BSS4-20, BSS21-63, BSS32-49 and B-EB4. No SVOCs were detected in the samples; analytical results for SVOCs in these samples were therefore coded UJ. At least one surrogate was below the acceptable surrogate recovery range for the following samples: BSS32-9 (8080A), BSS34-2 (8080A), MW1-2 (8080A), B-EB3 (8080A) and CS-BSS32-30 (8240B). These data were not coded as estimated because the analyses of these samples required a dilution. Sample dilutions resulted in the dilution of at least one surrogate to concentrations below method reporting limits. This is a common occurrence when investigative samples exhibit high constituent of interest concentrations. Matrix spike/duplicate matrix spike recoveries for metals analyses were out of range or were not calculated because the analyte concentration in the investigative sample was significantly higher than the added spike concentration. This prevented the accurate evaluation of the spike recovery. Based on a review of the case narrative supplied by the analytical laboratory and the laboratory's internal QA/QC, these data were not qualified.

7.2.4 QA/QC for Groundwater Chemical Data

The groundwater chemical analytical results from the RFI were validated based on the result of the QA/QC procedures. Trip blanks, equipment rinsate blanks, method blanks, surrogate recoveries, and matrix spike/matrix spike duplicate data were used to validate the groundwater data from the piezometers.

7.2.4.1 Blanks

No analytes were detected in the trip blanks or the method blanks associated with the groundwater samples. Trace concentrations of chloroform, TCE, bromodichloromethane, PCE and dibromochloromethane was detected in equipment rinsate blanks collected in November

1997. Detectable concentrations of TCE and PCE in the equipment blank is likely the result of carry over from using the decontaminated sampling hose instead of new sample hose between wells. Thereafter, new hoses were used. Chloroform, bromodichloromethane and dibromochloromethane were detected in field blank sample B-FB5, which seems to indicate the detections of these chemicals in B-EB4 are the result of collecting the equipment rinsate blank with Facility water, rather than a cross-contamination problem. Equipment blanks B-EB5 and B-EB6, collected in January 1998, were collected with distilled water. No VOCs were detected in B-EB5 and only a trace level of chloroform was detected in B-EB6. Trace concentrations of chloroform, bromodichloromethane, and toluene were detected in equipment rinsate blank samples correlating to the piezometer samples (EB_030699 and EB_030799). Associated groundwater data were qualified accordingly following EPA guidelines.

7.2.4.2 Duplicates

The calculated RPD values support the groundwater analytical data.

7.2.4.3 Completeness

The requested groundwater analyses were performed as requested.

7.2.4.4 Holding Times

The samples were prepared and analyzed within the appropriate holding times with the exception of sample PZ2_030699. The nitrate sample was analyzed one day past holding time. The result was qualified as an estimated concentration.

7.2.4.5 Surrogate and spike recovery

One of the surrogates was outside surrogate recovery limits for VOC analyses for samples MW2_011498, MW4S_011498 and B-EB6 (January 1998). As a result, VOC detections in these samples were coded with a J and non-detected VOC results were qualified with a UJ. Four of the surrogates for the SVOC analysis of groundwater sample B-EB4 (November 1997) were outside control limits. The SVOC results for equipment blank sample B-EB4 were qualified as unusable and were qualified as R. No SVOCs were detected in samples associated with this equipment blank, so this did not affect the investigation.

The matrix spike/duplicate matrix spike recovery of TCE for groundwater samples from MW1I and MW3I in November 1997 and MW4S in January 1998 were not calculated due to the significantly higher concentration in the investigative sample which prevented the accurate evaluation of the spike recovery. The associated data were not qualified as the results were

reasonable when compared with the range of results from these locations. The matrix spike recovery of aluminum, iron, and lead for groundwater sample MW4S (November 1997) was not calculated due to high concentrations in the investigative sample. The matrix spike/duplicate matrix spike recovery of TCE for sample MW4S_011498 (January 1998) was not calculated due to the significantly higher concentration of TCE in the investigative sample.

7.3 POTENTIAL RECEPTORS AND POTENTIAL EXPOSURE PATHWAYS

The result of the investigation into potential receptors is summarized in this section, including the human use of the Facility, ecology of the Facility, demographics, endangered or threatened species and groundwater use.

7.3.1 Human Use of the Facility

The Facility and adjacent lands are zoned for heavy industrial use by the City of Omaha. Human use of the Facility is limited to adult employees, visitors, and truck drivers driving through the Facility on the access road to the adjacent VW&R Facility. There are no public areas, such as might be used for recreation or hunting, at the Facility or on adjacent lands. Residences are located approximately 200 feet east of the Facility. These residences are located uphill from the Facility. The prevailing wind direction during the winter months is from the northwest, so the residences are downwind of the Facility during that time. During most of the year, the prevailing wind direction is from the southeast, so the residences are upwind of the Facility most of the time.

7.3.2 Ecology of the Facility

The ecology of the Facility area is urban. There are no documented occurrences of threatened or endangered species at or near the Facility (Twedt, 1997).

7.3.3 Demographics

The Facility lies near the boundary of two census tracts, Tract 31 and 32, in the Omaha area. Because of the Facility's close proximity to the census tract boundary, the Union Pacific Railroad, demographic data from both tracts are reported. The Facility lies within Tract 32. This tract is bound by Interstate 80 to the north, the Union Pacific Railroad to the west, 24th Street to the east, and Q Street to the south. Tract 31, located west of Tract 32, is bound by Interstate 80 to the north, the Union Pacific Railroad to the east, 42nd Street to the west, and Q Street, 36th Street, L Street and the Burlington Northern Railroad to the south. Demographic data were obtained from the 1990 U.S. Census.

Of the 3147 persons in Tract 31, 1517 were male, 1630 were female; 934 (30%) were 21 years old or younger, 962 (31%) were aged 22 to 39 years, 645 (21%) were aged 40 to 64 years, 577 (18%) were aged 64 to 84 years, and 29 (less than 1%) were 85 years and older (U.S. Census Bureau, 1997). All persons were in an urbanized area.

Of the 1259 households in Tract 31, 69% were classified as families; 88% consisted of four persons or less. Tract 31 contains 1314 housing units, with an approximate 95% rate of occupancy. Approximately 55% of persons (1728 persons aged 5 years and over) were in the same house as in 1985 (U.S. Census Bureau, 1997).

Of the 1925 persons in Tract 32, 929 were male, 996 were female; 533 (28%) were 21 years or younger, 546 (28%) were aged 22 to 39 years, 400 (21%) were aged 40 to 64 years, 350 (18%) were aged 64 to 84 years, and 96 (5%) were 85 years and older (U.S. Census Bureau, 1997). All persons were in an urbanized area.

Of the 943 households in Tract 32, 44% were classified as families; 92% consisted of four persons or less. Tract 32 contains 1036 housing units, with an approximate 94% rate of occupancy. Approximately 47% of persons (913 persons aged 5 years and older) were in the same house as in 1985.

7.3.4 Groundwater Use

The Douglas County Health Department is unaware of any domestic drinking water wells located within 1 mile of the Facility (PRC, 1992). A search of well records at the Nebraska Conservation Survey turned up no wells completed within the glacial deposits within 1 mile of the Facility (EDR, 1997). The City of Omaha provides drinking water to most city residents and businesses, including those in the Facility area.

The City of Omaha obtains its drinking water from two main sources (PRC, 1992). The first source is a surface-water intake on the Missouri River, located approximately 13 miles upstream from the Facility area. The second source of Omaha's drinking water is a well field located adjacent to the Platte River approximately 10 miles south of the Facility. Each source supplies about half of the city's water over the course of a year. The municipal wells near the Platte River range in depth from 45 to 255 feet and are completed in alluvial and glacial formations. In addition, the municipal water system occasionally obtains water from peak-use wells located west of 120th Street, over 6 miles west of the Facility (PRC, 1992). These peak-use wells range in depth from 150 to 300 feet and are completed in Dakota Sandstone. The

glacial overburden is cased off in these wells. Based on regional groundwater flow (University of Nebraska, 1986), these wells are not downgradient of the Facility.

8.0 RISK CHARACTERIZATION

This section integrates the results of the RFI with pre-RFI results to evaluate the nature and extent of any release of hazardous constituents at the Facility and the potential risk posed by detected constituents.

8.1 SOIL

Soil COCs, potential receptors and exposure pathways, exposure point concentrations, areas of concern, and identification of areas that may need to be addressed by corrective action are described in the following sections.

8.1.1 COCs

The first step in the risk characterization was to refine the initial list of COPCs based on detected concentrations in soil samples collected at the Facility. This entailed comparing the maximum of detected concentrations to the RBC and SSLair. Table 23 presents the list of COPCs detected in soil (with the exception of metals, which were considered separately), the screening criteria, and the maximum concentration at which each chemical was detected. For three detected chemicals, neither an RBC or SSLair has been developed to which soil data could be compared. These chemicals were evaluated on a case-by case basis as noted on Table 23. Metals concentrations were compared to native concentrations and concentration in soil at the adjacent VW&R facility and were observed to be within the range of native soil conditions (Shacklette & Boerngen, 1984). Therefore, metals concentrations are not of concern with regard to excess risk posed by the Facility conditions.

After comparison to RBCs and SSLs, 12 detected constituents remained for consideration. With the exception of one chemical, all of these chemicals were selected as constituents of concern (COCs) for the purposes of risk characterization for soil. Pentachlorophenol was not identified as a COC because it was detected in only 1 out of 38 soil samples. The eleven COCs include seven pesticides and four VOCs, as listed in Table 24. Table 25 presents concentrations detected in soil for the eleven COCs.

Several samples collected and analyzed during the Phase I Investigation had quantitation limits that were higher than the risk-based criteria, but this did not affect the evaluation of the data. The samples were limited to a few soil borings, and other constituents were detected above the

risk-based criteria at these locations. Therefore, no locations were ruled out as an area of potential concern because constituents were not detected where the quantitation limit was higher than the risk-based criteria. Additionally, quantitation limits above the risk-based criteria were generally limited to one or two sampling intervals, with the exception of borings BP11 and BP13.

8.1.2 Potential Receptors and Exposure Routes

Based on current and planned future industrial use of the Facility, potential receptors are limited to future long-term on-site industrial workers and short-term on-site construction/utility workers. The area of concern is not used currently; there are no on-site workers. The fence surrounding the Facility prevents others from accessing the Facility. The planned use for the Facility is industrial.

Potential routes for exposure include the following:

- Incidental ingestion
- Dermal contact
- Inhalation of vapors or resuspended particulates (i.e., dust).

Exposure would require removal of the Permalon liner installed as an IRM and removal of the concrete foundations west of the road.

8.1.3 Exposure Point Concentrations

Chemical concentrations that are considered representative of the average concentration to which an individual might be exposed over an extended period (i.e., "exposure point concentrations") were estimated using the Facility data. U.S. EPA stipulates that the exposure point concentration estimates should be based on the 95% upper confidence limit (95% UCL) of the arithmetic mean to account for uncertainty in estimating the mean concentrations (U.S.EPA, 1992). The equations and data set used to calculate the 95% UCLs for each of the COCs are presented in Appendix E.

The data set used to calculate exposure point concentrations was identified based on the following analysis. Some of the chemical data from the Facility are not relevant to evaluating risk to future on-site workers via the potential exposure routes. For example, some data were collected from a depth that would preclude exposure. Other data were collected in areas that turned out to be not significantly affected by historical operations. Therefore, the Facility data

were analyzed to identify the data set relevant to evaluating risk, and that data set was then used in the exposure point concentration calculation. The following observations were made relevant to this data analysis process:

- Soil samples collected from locations east of the road were either non-detect or contained very low concentrations for all of the COCs; soil in this area has not been significantly impacted, if at all. This is illustrated by soil results for TCE (Figure 13) and dieldrin (Figure 15). Therefore, analytical data from east of the road were excluded from the data set.
- Soil samples collected from locations immediately west of the Facility boundary to characterize the off-site extent of constituents in surface soil were not significantly impacted by pesticide COCs. Specifically, analytical results for soil samples collected off-site near the northern portion of the site (BSS 39 through BSS 42) were non-detect for all the pesticide COCs. In addition, analytical results from BSS-50, the westernmost off-site sample, were also non-detect for all pesticide COCs. Therefore, analytical results for pesticides for these samples were excluded from the data set.
- The volatile COCs were used as indicator constituents during the RFI, meaning that they were analyzed by both the on-site mobile laboratory and offsite fixed laboratory. For purposes of calculating exposure point concentrations, the maximum value (detected concentration or quantitation limit) was used.
- Exposure to COCs in soil via incidental ingestion, dermal contact and inhalation of resuspended particulates requires direct contact with soil, which is generally restricted to the uppermost 1 to 2 feet of soil. It is theoretically possible for deeper soil to be placed at the surface at some time in the future, such as during redevelopment or regrading of the site. However, it is very unlikely that soil below 12 feet below ground surface would be redistributed in this manner. Exposure to COCs in soil via inhalation of vapors from soil depends on the volatilization of COCs and migration of the vapors to the ground surface. Volatilization is expected to be most significant from the uppermost 10 feet of soil and most significant for volatile COCs as compared to pesticide COCs. The highest concentrations of the pesticide COCs occur in the uppermost 2 feet of soil, although pesticides were detected at elevated concentrations up to 9 feet bgs. The highest concentrations of the volatile COCs were detected in the uppermost 12 feet of soil. Volatile COCs were detected in somewhat elevated concentrations in samples collected below 30 feet bgs, but the risk of exposure to these soils or to vapors emanating from them is very low. Based on these considerations, data below 12 feet bgs were excluded from the data set.

8.1.4 Areas of Concern

Areas of the Facility that contribute most significantly to the overall risk were identified by comparing the representative concentration for each of the COPCs to an ISC for soil. These

intermediate criteria were calculated following the methodology provided in U.S. EPA, Region IX Preliminary Remediation Goals (PRGs) (U.S. EPA, 1998c). The methodology prescribed in this document is preferred to that prescribed by Region III because it incorporates exposure through all of the identified exposure pathways including ingestion, dermal contact, and inhalation of particulates or vapors while the methodology provided by Region III incorporates only the ingestion of soil pathway. U.S. EPA, Region IX PRGs combine current U.S. EPA toxicity values with standard exposure factors to estimate concentrations in environmental media (in this case, soil) that are protective of human health, including sensitive subgroups, over a lifetime. For purposes of this evaluation, default input parameters prescribed by U.S. EPA for an adult industrial worker were used. Noncarcinogenic and carcinogenic toxicity criteria were based on values provided in the U.S. EPA Integrated Risk Information System (IRIS) database (U. S. EPA, 1999b). Target risk levels of 1×10^{-5} (as an aggregate target risk level for all chemicals; risks for individual chemicals did not exceed 3×10^{-6}) and hazard index of 1 were used for carcinogenic and noncarcinogenic chemicals, respectively. The calculations and input parameters are presented in Appendix E.

Based on a comparison of intermediate screening criteria to site-wide representative concentrations, aldrin and dieldrin were the COCs that most significantly exceeded their respective screening criteria. The highest concentrations of these chemicals were detected in the southern portion of the Facility, west of the paved road that bisects the Facility. Somewhat lower, but still significantly elevated concentrations of these chemicals were detected in the central portion of the Facility, west of the paved road.

8.1.5 Identification Of Areas Potentially Requiring Corrective Action

Areas potentially requiring corrective action to reduce the residual risk to below acceptable levels were identified through an iterative process. This process entailed removing the analytical data for specific sample locations, beginning with those within the general areas identified in the previous step, and recalculating the site-wide representative concentrations. These updated representative concentrations were used to estimate a residual risk based on the same exposure assumptions and toxicity criteria used to estimate the intermediate criteria. This process was repeated until the residual risk was equal to or below a cancer risk of 1×10^{-5} (i.e., as an aggregate; risks for individual constituents did not exceed 3×10^{-6} in the final analysis) and noncancer hazard index of 1. Assuming corrective measures addressed the areas illustrated in Figure 20 (the southern portion of the Facility west of the road) the residual cancer risk is 1×10^{-5} and the residual noncancer hazard index is 0.3. The spreadsheets used for these calculations are provided in Appendix E.

8.1.6 Qualitative Evaluation of Future Construction/Utility Worker Scenario

A future construction/utility worker scenario was qualitatively evaluated based on the quantitative results of the adult industrial worker scenario. Assuming corrective measures addressed the areas illustrated in Figure 20, the residual cancer risk for a future industrial worker would be 1×10^{-5} and the residual noncancer hazard index would be 0.3. The exposure factors (e.g., exposure frequency) assumed for the industrial worker are different from those that are generally assumed for a construction/utility worker. The exposure factors that are the most different include the following:

- Exposure duration for a future industrial worker is assumed to be 25 years, while a construction/utility worker is generally expected to be present at a construction site for 1 year or less
- Soil ingestion rate for a future industrial worker is assumed to be 50 milligrams per day (mg/day), while the ingestion rate for a construction/utility worker is assumed to be 480 mg/day
- The particulate emission factor (PEF) for a future industrial worker is assumed to be 1.316×10^9 cubic meters per kilogram (m^3/kg), while the PEF for the construction/utility worker is assumed to be $1 \times 10^6 \text{ m}^3/\text{kg}$.

In addition, because the construction/utility worker has a short-term exposure duration (i.e., 1 year), it is more appropriate to use a sub-chronic reference dose (RfD) to evaluate noncarcinogenic health effects rather than the chronic RfD used for the industrial worker; sub-chronic RfDs are generally a factor of 10 higher than chronic RfDs. Based on these factors, the noncarcinogenic risk to a construction/utility worker is approximately the same as that calculated for the industrial worker (based on an increased soil ingestion rate and PEF and increased RfD). The carcinogenic health risk to a construction/utility worker is approximately a factor of 10 lower than that calculated for the industrial worker (based on lower exposure duration, and increased soil ingestion rate and PEF). Therefore, the risk to future construction/utility workers would be less than or equal to those calculated for the industrial worker.

8.2 GROUNDWATER

Groundwater COCs, potential receptors and exposure pathways, and areas of concern with regard to groundwater are described in the following sections.

8.2.1 COCs

As with soil, groundwater data were used to refine the initial list of constituents to a list of COCs. The data presented in Section 7 were used to identify COPCs to be evaluated in terms of risk to potential receptors. Maximum detected concentrations were compared to federal MCLs. The presence of several VOCs in groundwater, including TCE, PCE, DCE, and carbon tetrachloride, was evaluated relative to potential receptors and exposure routes. COCs in groundwater are listed in Table 24.

8.2.2 Potential Receptor and Exposure Routes

Groundwater from the glacial deposits is not used in the area. In the unlikely event of future use of groundwater within these units, the potential for exposure to COCs may exist. The City of Omaha currently restricts such use through zoning ordinances and permit requirements.

Groundwater discharge from the I Sand Unit to the ravine in Spring Lake Park may present a potential pathway for exposure if groundwater COCs are present. However, groundwater COCs were not detected in samples collected from the I Sand Unit in the three temporary piezometers located upgradient of the ravine. Therefore, there is no exposure to groundwater COCs at Spring Lake Park. The reduction in concentration of COCs between the source area and MW7I suggests significant physical and/or chemical attenuation of the plume.

Groundwater geochemical conditions in and downgradient of the source area indicate reductive dechlorination is an important attenuating process at the Facility. Continued attenuation of COCs along the groundwater flow path at rates observed at the Facility will result in attenuation of the plume before it migrates 5,000 feet. This is based on simple assumptions of groundwater flow conditions and first order decay of COCs.

8.2.3 Area of Concern

The primary area of concern with regard to groundwater under current conditions is the area of groundwater VOCs within the S Stratified Unit in the MW4S area. The plume of VOCs in the I Sand Unit is of concern relative to future use and potential migration toward discharge points.

9.0 CONCLUSIONS

Conclusions from the RFI, in regard to environmental setting, type, level, and location of COCs, risk, and potential corrective measures technologies, are presented in the following sections.

9.1 ENVIRONMENTAL SETTING

The Facility is located in an upland area approximately 2 miles west of the Missouri River. There are no surface water bodies at or near the Facility. The site is relatively small and the ground surface slopes generally east to west. Residential areas near the Facility are located east of and uphill from the Facility, eliminating the potential for surface runoff from the Facility to have flowed toward these properties. The Facility is currently vacant. Future use of the Facility would most likely be industrial.

Clayey silt (loess) is the predominant surficial geologic unit at the Facility. The loess is relatively uniform in composition and hydraulic properties and is underlain by a sequence of glacial deposits at approximately 60 feet bgs. The glacial deposits are highly variable in their composition and hydraulic properties. The glacial deposits are underlain by bedrock at an approximate depth of 200 feet bgs.

Saturated conditions are present within the glacial deposits, in the S Stratified Unit and the I Sand Unit. The I Sand Unit is the uppermost continuous water-bearing unit at the Facility. The S Stratified Unit is laterally discontinuous and highly variable in composition. Groundwater occurs in this unit, but the unit is not likely to be a usable source of groundwater. However, the unit is a pathway for groundwater impacted by COCs. Groundwater in this unit will migrate downward into the I Sand Unit where the underlying S Till Unit is thin or absent.

The S Till Unit, like the deeper I Till Unit, is a sandy lean clay to lean clay textured till. Both till units have a low (e.g., 10^{-7} to 10^{-8} cm/s) hydraulic conductivity and where present will form a barrier to groundwater flow. The S Till Unit is thin (i.e., less than one foot thick) and may be discontinuous in areas of the Facility where groundwater in the S Stratified Unit is affected by COCs.

The I Sand Unit is comprised of medium to coarse grained, poorly graded sand. The unit is observed to be approximately 25 feet thick, fully saturated, and hydraulically confined. The unit is underlain by the laterally continuous I Till Unit. Groundwater flow in the I Sand Unit appears to be primarily horizontal and relatively rapid.

9.2 TYPE, LEVEL, AND LOCATION OF COCs

The distribution of COCs in soil and groundwater is described as follows.

9.2.1 Soil

Pesticides and VOCs were detected in soil at levels that may present an unacceptable risk to human health. These areas are west of the road that bisects the Facility. Pesticides are limited primarily to the uppermost 12 feet bgs, but VOCs extend to the depth of the water table, which is approximately 70 feet bgs.

9.2.2 Groundwater

Groundwater infiltrating through the soil matrix over time has dissolved VOCs, particularly PCE and TCE, and carried them downward into the uppermost water-bearing units at the Facility. The highest concentrations of VOCs in groundwater at the Facility are within the S Stratified Unit in an area underlying relatively high soil VOC concentrations. The S Till Unit is relatively thin and may be discontinuous in some areas where the S Stratified Unit contains relatively high VOC concentrations. Groundwater impacted by VOCs appears to have migrated downward through gaps in the S Till Unit into the underlying I Sand Unit and then has migrated along the prevailing flow direction to the east-southeast.

COCs have impacted the I Sand Unit where soil was impacted to the depth of the water table and where the S Till Unit was thin or absent. The main source for TCE and PCE appears to be in the MW4S area at the west side of the Facility. There appears to be a source for carbon tetrachloride further to the south near MW3I. A plume of TCE extends to the southeast from the northwestern part of the Facility toward MW7I and a plume of carbon tetrachloride extends to the southeast from the southwestern part of the Facility toward MW8I.

There is an order of magnitude decline in VOC concentration between the S Stratified Unit at MW4S and the I Sand Unit at MW7I. This decline appears to be the result of a combination of hydraulic barriers to transport of VOCs, in situ dechlorination and other natural processes. Within the I Sand Unit, the plume appears to be relatively small in width and vertical thickness. In the vertical dimension at MW7I, groundwater VOC concentrations were relatively high only in the center 10 feet of the 25-foot thick unit. This is consistent with a stable groundwater flow direction and relatively high groundwater velocity, which would tend to limit lateral spread of the plume.

The groundwater flow system at the Facility appears to have a natural capacity to attenuate VOCs. This is supported by the following: 1) the absence of aromatic hydrocarbons such as toluene in groundwater, although they are present at relatively high concentrations in soil, 2) an apparent loss of TCE, PCE, and 1,1,1-TCA along the flowpath between the source zone near

MW4S and the downgradient monitoring well MW7I, 3) the presence of geochemical indicators of the degradation of TCE, PCE, 1,1,1-TCA, and carbon tetrachloride, and 4) the development of an anaerobic zone in the I Sand Unit in the northwestern part of the Facility, which is conducive to reductive dechlorination of VOCs such as TCE.

Over 90 percent of the TCE concentration at MW4S is lost as groundwater migrates to MW7I. However, VOC concentrations at downgradient monitoring wells remain above the federal MCLs, suggesting a potentially unacceptable risk to future receptors if the plume continues to migrate. While the groundwater system has been monitored since 1997, the monitoring interval is too short to identify the presence of a temporal trend in VOC concentration. Long-term monitoring would be needed to evaluate the potential for loss of VOCs over time within the plume. Such data would be needed to conclude that the attenuation capacity of the groundwater flow system is sufficient to limit plume migration, thereby mitigating potentially unacceptable health risks.

The Spring Lake Park area is a logical point for groundwater to discharge from the I Sand Unit approximately one mile downgradient of the Facility. Hydrostratigraphic observations and an evaluation of regional groundwater flow support this conclusion. The hydrostratigraphic sequence observed in all three borings drilled in the Spring Lake Park area correlates with the hydrostratigraphy observed at the Facility. The hydrostratigraphy observed at the Facility and in the Spring Lake Park area also correlates with that observed by the U.S.GS at an outcrop located south of Spring Lake Park. The I Sand Unit appears to be a tabular deposit that is relatively extensive laterally. At Spring Lake Park, the I Sand Unit is completely dissected by a northwest to southeast trending ravine. The base of the ravine is within the till underlying the sand. Groundwater flowing within the sand unit would discharge in the ravine. Discharge from this unit is probably the source of springs observed in the past at Spring Lake Park.

Groundwater flow between the Facility and the Spring Lake Park area is toward the east-southeast. This is supported by published regional groundwater flow maps, water levels measured at the Facility and in the temporary piezometers installed in the Spring Lake Park Area, and on the elevation of the mapped sand outcrop south of Spring Lake Park. The ravine at Spring Lake Park is the closest discharge point for the sand unit east-southeast of the Facility.

Groundwater discharge from the I Sand Unit to the ravine in Spring Lake Park may present a potential pathway for exposure, to the extent groundwater COCs were present. However,

groundwater COCs were not detected in samples collected from the I Sand Unit in the three temporary piezometers located upgradient of the ravine. Therefore, there is no exposure to groundwater COCs at Spring Lake Park. It is likely that COCs have attenuated between the Facility and Spring Lake Park, given that Spring Lake Park is nearly one mile from the Facility. TCE concentrations declined more than 90 percent over just 700 feet from MW4S to MW7I, and natural processes of sorption, diffusion, dispersion, and chemical degradation will continue to attenuate COCs along the groundwater flow path. Based on the strong evidence of chemical degradation at the Facility and continued degradation in the downgradient direction, the front of the plume of TCE would be expected to degrade to non-detectable concentrations before reaching the Spring Lake Park area.

9.3 RISK CHARACTERIZATION

The level of risk associated with soil and groundwater, based on Facility conditions, are described as follows.

9.3.1 Soil

Chemical concentrations that are considered representative of the average concentration to which an individual might be exposed over an extended period were estimated using soil analytical data. Areas of the Facility that contribute most significantly to the overall risk were identified by comparing the representative concentration for each of the COCs to criteria prescribed by U.S. EPA for an adult industrial worker. The criteria are also protective of a short-term construction/utility worker. The areas of soil that require corrective action to reduce risk to acceptable levels are located west of the road that bisects the Facility, and generally in the southwestern part of the Facility. Aggregate target risk levels of 1×10^{-5} (risks for individual constituents did not exceed 3×10^{-6}) and hazard index of 1 were used for carcinogenic and noncarcinogenic chemicals, respectively. Pesticides, particularly aldrin and dieldrin, are present at concentrations that may pose an unacceptable health risk to people working in this area, should the existing Permalon liner be removed at some point in the future and the workers incidentally ingest, come into contact with, or inhale dust. If this area is addressed by corrective action, the residual risk will at a level that generally would be considered to be acceptable.

9.3.2 Groundwater

Impacted groundwater constitutes a low long-term potential risk based on the goal of protecting human health and the environment. Groundwater within the glacial deposits is not used in this area. There is no planned groundwater development in the area, which has long been

developed and is fully serviced by municipal water. The municipal water supply points are located far from the Facility and are not at risk of being affected by COCs from the Facility. Groundwater development at the Facility and in the area downgradient of the Facility is restricted by the City of Omaha. There is no exposure to groundwater COCs at Spring Lake Park.

There is no ecological risk associated with the Facility. The Facility is an urban setting, and no threatened or endangered species are present.

9.4 POTENTIAL CORRECTIVE MEASURES TECHNOLOGIES

The list of potential CM technologies was prepared by eliminating from consideration those technologies whose use would be precluded by Facility and/or waste characteristics.

9.4.1 Soil

The corrective action objective for soil is to achieve an acceptable level of risk to human health and to prevent transfer of impacts to other media, such as air, that would result in unacceptable risk. Potential corrective measures technologies for addressing soil are listed in Table 26. Potential corrective measures technologies will be evaluated during the CMS.

9.4.2 Groundwater

The corrective action objective for groundwater is to mitigate the potential long-term risk by addressing migration of impacted groundwater toward potential receptors and to prevent exposure to impacted groundwater. Potential corrective measures technologies for addressing groundwater are listed in Table 26. Potential corrective measures technologies will be evaluated during the CMS.

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TABLE 1



CONSTITUENTS OF POTENTIAL CONCERN

4120 Buckingham Place
Omaha, Nebraska

ANALYTE	CAS No.
<i>Volatile Organic Compounds:</i>	
1,1,1-Trichloroethane	71-55-6
1,1,2,2-Tetrachloroethane	79-34-5
1,1,2-Trichloroethane	79-00-5
1,1-Dichloroethane	75-34-3
1,1-Dichloroethene	75-35-4
1,2-Dichloroethane	107-06-2
1,2-Dichloroethene (total)	540-59-0
1,2-Dichloropropane	78-87-5
2-Butanone	78-93-3
2-Hexanone	591-78-6
4-Methyl-2-pentanone	108-10-1
Acetone	67-64-1
Benzene	71-43-2
Bromodichloromethane	75-27-4
Bromoform	75-25-2
Bromomethane	74-83-9
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Chlorobenzene	108-90-7
Chloroethane	75-00-3
Chloroform	67-66-3
Chloromethane	74-87-3
cis-1,3 -Dichloropropene	10061-02-5
Dibromochloromethane	124-48-1
Ethyl benzene	100-41-4
Methylene chloride	75-09-2
Styrene	100-42-5
Tetrachloroethene	127-18-4
Toluene	108-88-3
trans-1,3-Dichloropropene	10061-02-6
Trichloroethene	79-01-6
Vinyl acetate	108-05-4

TABLE 1



CONSTITUENTS OF POTENTIAL CONCERN

4120 Buckingham Place
Omaha, Nebraska

ANALYTE	CAS No.
Vinyl chloride	75-01-4
Xylenes (total)	1330-00-0
<i>Semivolatile Organic Compounds:</i>	
1,2,4-Trichlorobenzene	120-82-1
1,2-Dichlorobenzene	95-50-1
1,3-Dichlorobenzene	541-73-1
1,4-Dichlorobenzene	106-46-7
2,4,5-Trichlorophenol	95-95-4
2,4,6-Trichlorophenol	88-06-2
2,4-Dichlorophenol	120-83-2
2,4-Dimethylphenol	105-67-9
2,4-Dinitrophenol	51-28-5
2,4-Dinitrotoluene	121-14-2
2,6-Dinitrotoluene	606-20-2
2-Chloronaphthalene	91-58-7
2-Chlorophenol	95-57-8
2-Methylnaphthalene	91-57-6
2-Methylphenol	95-48-7
2-Nitroaniline	88-74-4
2-Nitrophenol	88-75-5
3,3'-Dichlorobenzidine	91-94-1
3-Nitroaniline	99-09-2
4,6-Dinitro-2-methylphenol	534-52-1
4-Bromophenyl-phenylether	101-55-3
4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7
4-Chloroaniline	106-47-8
4-Chlorophenyl-phenyl ether	7005-72-3
4-Methylphenol	106-44-5
4-Nitroaniline	100-01-6
4-Nitrophenol	100-02-7
Acenaphthene	83-32-9
Acenaphthylene	208-96-8

TABLE 1



CONSTITUENTS OF POTENTIAL CONCERN

4120 Buckingham Place
Omaha, Nebraska

ANALYTE	CAS No.
Anthracene	120-12-7
Benzo(a)anthracene	56-55-3
Benzo(a)pyrene	50-32-8
Benzo(b)fluoranthene	105-99-2
Benzo(g,h,i)perylene	191-24-2
Benzo(k)fluoranthene	207-08-9
Benzoic acid	65-85-0
Benzyl alcohol	100-51-6
bis(2-Chloroethoxy) methane	111-91-1
bis(2-Chloroethyl) ether	111-44-4
bis(2-Chloroisopropyl) ether	108-60-1
bis(2-Ethylhexyl)phthalate	117-81-7
Butylbenzylphthalate	85-68-7
Chrysene	218-01-9
Di-n-butylphthalate	84-74-2
Di-n-octylphthalate	117-84-0
Dibenz(a,h)anthracene	53-70-3
Dibenzofuran	132-64-9
Diethylphthalate	84-66-2
Dimethylphthalate	131-11-3
Fluoranthene	206-44-0
Fluorene	86-73-7
Hexachlorobenzene	118-74-1
Hexachlorobutadiene	87-68-3
Hexachlorocyclopentadiene	77-47-4
Hexachloroethane	67-72-1
Indeno(1,2,3-cd)pyrene	193-39-5
Isophorone	78-59-1
N-Nitroso-di-n-dipropylamine	621-64-7
N-Nitrosodiphenylamine	86-30-6
Naphthalene	91-20-3
Nitrobenzene	98-95-3
Pentachlorophenol	87-86-5

TABLE 1

CONSTITUENTS OF POTENTIAL CONCERN

4120 Buckingham Place
Omaha, Nebraska

ANALYTE	CAS No.
Phenanthrene	85-01-8
Phenol	108-95-2
Pyrene	129-00-0
<i>Pesticides/Polychlorinated Biphenyls:</i>	
4,4'-DDD	72-54-8
4,4'-DDE	72-55-9
4,4'-DDT	50-29-3
Aldrin	309-00-2
alpha-BHC	319-84-6
alpha-Chlordane	5103-71-9
Aroclor-1016	12674-11-2
Aroclor-1221	11104-28-2
Aroclor-1232	11141-16-5
Aroclor-1242	53469-21-9
Aroclor-1248	12672-29-6
Aroclor-1254	11097-69-1
Aroclor-1260	11096-82-5
beta-BHC	319-85-7
delta-BHC	319-86-8
Dieldrin	60-57-1
Endosulfan I	959-98-8
Endosulfan II	33213-65-9
Endosulfan sulfate	1031-07-8
Endrin	72-20-8
Endrin ketone	53494-70-5
gamma-BHC (lindane)	58-89-9
gamma-Chlordane	5103-74-2
Heptachlor	76-44-8
Heptachlor epoxide	1024-57-3
Methoxychlor	72-43-5
Toxaphene	8001-35-2

TABLE 1



CONSTITUENTS OF POTENTIAL CONCERN

4120 Buckingham Place
Omaha, Nebraska

ANALYTE	CAS No.
<i>Metals:</i>	
Aluminum	7429905
Antimony	7740360
Arsenic	7740382
Barium	7440393
Beryllium	7440417
Cadmium	7440439
Chromium	18540299
Cobalt	7440484
Copper	7440508
Cyanide	57125
Iron	7439896
Lead	7439921
Magnesium	
Manganese	7439965
Mercury	7439976
Nickel	7440020
Selenium	7782492
Silver	7440224
Vanadium	7440622
Zinc	7440000

TABLE 2

SUMMARY OF SOIL BORING PROGRAM



4120 Buckingham Place
Omaha, Nebraska

Soil Boring Number	Date Drilled	Termination Depth (ft bgs)	Sample Identification Number	Sample Depth ¹ (ft bgs)
BSS1	22-Apr-97	12	MBSS1-12	12
BSS2	22-Apr-97	12	MBSS2-12	12
BSS3	22-Apr-97	12	MBSS3-12	12
BSS4	22-Apr-97 (direct-push)	20	PBSS4-2	4
	8-Jun-97 (augers)	20	PBSS4-10	10
			MBSS4-12	12
			BSS4-20	20
			MBSS4-20	20
BSS5	22-Apr-97	12	MBSS5-12	12
BSS6	22-Apr-97	12	MBSS6-12	12
BSS7	22-Apr-97	12	MBSS7-12	12
BSS8	22-Apr-97 (direct-push)	20	PBSS8-2	2
	8-Jun-97 (augers)	20	PBSS8-10	10
			MBSS8-12	12
			MBSS8-20	20
			PBSS8-20	20
			BSS8-20	20
BSS9	22-Apr-97	12	MBSS9-12	12
BSS10	22-Apr-97	12	MBSS10-12	12
BSS11	23-Apr-97	12	MBSS11-12	12
BSS12	23-Apr-97	12	MBSS12-12	12
BSS13	23-Apr-97	12	MBSS13-12	12
BSS14	23-Apr-97	12	MBSS14-12	12
BSS15	23-Apr-97	12	MBSS15-12	12
BSS16	23-Apr-97	12	MBSS16-12	12
BSS17	24-Apr-97	12	MBSS17-12	12
BSS18	27-Apr-97 (direct-push)	20	PBSS18-2	2
	6-Jun-97 (augers)	75	PBSS18-10	10
			MBSS18-12	12
			MBSS18-20	20
			PBSS18-20	20
			BSS18-20	20
			BSS18-27	27
			MBSS18-30	30
			BSS18-30	30

¹ Base of sampled interval
ft bgs - Feet below ground surface

TABLE 2

SUMMARY OF SOIL BORING PROGRAM



4120 Buckingham Place
Omaha, Nebraska

Soil Boring Number	Date Drilled	Termination Depth (ft bgs)	Sample Identification Number	Sample Depth ¹ (ft bgs)
			PBSS18-30	30
			MBSS18-40	40
			PBSS18-40	40
			BSS18-40	40
			BSS18-48	48
			MBSS18-50	50
			PBSS18-50	50
			MBSS18-60	60
			BSS18-60	60
			PBSS18-60	60
			BSS18-64	64
			MBSS18-69	69
			BSS18-69	69
			BSS18-70	70
			MBSS18-75	75
			PBSS18-75	75
BSS19	24-Apr-97	12	MBSS19-12	12
BSS20	24-Apr-97	12	MBSS20-12	12
BSS21	24-Apr-97 (direct-push)	20	PBSS21-2	2
	8-Jun-97 (augers)	69	PBSS21-10	10
			MBSS21-12	12
			BSS21-12	12
			MBSS21-20	20
			BSS21-21	21
			BSS21-30	30
			PBSS21-30	30
			PBSS21-40	40
			PBSS21-50	50
			BSS21-52	52
			PBSS21-60	60
			MBSS21-63	63
			PBSS21-63	63
			BSS21-63	63
			MBSS21-69	69
			BSS21-77	77

¹ Base of sampled interval
ft bgs - Feet below ground surface

TABLE 2

SUMMARY OF SOIL BORING PROGRAM



4120 Buckingham Place
Omaha, Nebraska

Soil Boring Number	Date Drilled	Termination Depth (ft bgs)	Sample Identification Number	Sample Depth ¹ (ft bgs)
BSS22	24-Apr-97	12	MBSS22-12	12
BSS23	24-Apr-97	12	MBSS23-12	12
BSS24	24-Apr-97	12	MBSS24-12	12
BSS25	24-Apr-97	12	MBSS25-12	12
BSS26	24-Apr-97 (direct-push)	20	PBSS26-2	2
	5-Jun-97 (augers)	77	PBSS26-10	10
			MBSS26-12	12
			MBSS26-17.5	17.5
			BSS26-17.5	17.5
			PBSS26-20	20
			MBSS26-30	30
			BSS26-30	30
			MBSS26-40	40
			BSS26-40	40
			PBSS26-42	42
			BSS26-47	47
			MBSS26-50	50
			BSS26-50	50
			PBSS26-50	50
			MBSS26-59	59
			BSS26-59	59
			PBSS26-59	59
			BSS26-69	69
			PBSS26-69	69
			MBSS26-70	70
			MBSS26-77	77
			BSS26-77	77
BSS27	25-Apr-97	12	MBSS27-12	12
BSS28	25-Apr-97	12	MBSS28-12	12
BSS29	25-Apr-97	12	MBSS29-12	12
BSS30	25-Apr-97	12	MBSS30-12	12
BSS31	25-Apr-97	12	MBSS31-12	12
BSS32	10-Jun-97	59	MBSS32-9	9
			BSS32-9	9
			PBSS32-10	10

¹ Base of sampled interval
ft bgs - Feet below ground surface

TABLE 2

SUMMARY OF SOIL BORING PROGRAM

4120 Buckingham Place
Omaha, Nebraska



Soil Boring Number	Date Drilled	Termination Depth (ft bgs)	Sample Identification Number	Sample Depth ¹ (ft bgs)
			MBSS32-20	20
			BSS32-20	20
			PBSS32-20	20
			MBSS32-30	30
			PBSS32-30	30
			BSS32-30.5	30.5
			MBSS32-40	40
			BSS32-40	40
			PBSS32-40	40
			MBSS32-49	49
			BSS32-49	49
			PBSS32-49	49
			MBSS32-59	59
			BSS32-59	59
			PBSS32-59	59
BSS33	10-Jun-97	60	BSS33-5.5	5.5
			MBSS33-10	10
			BSS33-10	10
			PBSS33-10	10
			MBSS33-20	20
			PBSS33-20	20
			BSS33-21	21
			MBSS33-28.5	28.5
			BSS33-28.5	28.5
			PBSS33-28.5	28.5
			MBSS33-40	40
			BSS33-40	40
			PBSS33-40	40
			MBSS33-48	48
			BSS33-48	48
			PBSS33-48	48
			MBSS33-60	60
			BSS33-60	60
BSS34	6-Oct-97	22	BSS34-2	2
			BSS34-10	10

¹ Base of sampled interval
ft bgs - Feet below ground surface

TABLE 2

SUMMARY OF SOIL BORING PROGRAM



4120 Buckingham Place
Omaha, Nebraska

Soil Boring Number	Date Drilled	Termination Depth (ft bgs)	Sample Identification Number	Sample Depth ¹ (ft bgs)
			MBSS34-10	10
BSS35	6-Oct-97	10	BSS35-2	2
			MBSS35-2	2
BSS36	7-Oct-97	4	MBSS36-2	2
			BSS36-2	2
BSS37	6-Oct-97	32	MBSS37-20	20
			MBSS37-30	30
			BSS37-30	30
			BSS37-20	20
			BSS37-10	10
			BSS37-2	2
			MBSS37-10	10
			MBSS37-2	2
BSS38	7-Oct-97	4	MBSS38-2	2
			BSS38-2	2
BSS39	7-Oct-97	2	BSS39-2	2
			MBSS39-2	2
BSS40	7-Oct-97	2	MBSS40-2	2
			BSS40-2	2
BSS41	8-Oct-97	10	BSS41-2	2
			MBSS41-2	2
BSS42	8-Oct-97	8	BSS42-2	2
			MBSS42-2	2
BSS43	6-Oct-97	2	MBSS43-2	2
BSS44	8-Oct-97	2	MBSS44-2	2
BSS45	8-Oct-97	2	MBSS45-2	2
BSS46	8-Oct-97	2	MBSS46-2	2
BSS47	8-Oct-97	2	MBSS47-2	2
BSS48	8-Oct-97	2	MBSS48-2	2
BSS49	8-Oct-97	2	MBSS49-2	2
BSS50	8-Oct-97	2	MBSS50-2	2
BSS51	28-Jun-98	127.5	-	-
BSS52	20-Jun-98	127.5	BSS52-120	120
			BSS52-132	132
MW11	21-Oct-97	90	MW1-82	82

¹ Base of sampled interval
ft bgs - Feet below ground surface

TABLE 2

SUMMARY OF SOIL BORING PROGRAM

4120 Buckingham Place
Omaha, Nebraska



Soil Boring Number	Date Drilled	Termination Depth (ft bgs)	Sample Identification Number	Sample Depth ¹ (ft bgs)
			MW1-90	90
			MW1-71	71
			MW1-9	9
			MW1-2	2
MW2I	14-Oct-97	89	MW2-87	87
			MW2-2	2
			MW2-10	10
MW3I	16-Oct-97	88	MW3-2.5	2.5
			MW3-10	10
			MW3-75	75
MW4I	23-Oct-97	89.4	MW4D-5.5	5.5
			MW4D-10	10
			MW4D-80	80
MW4S	28-Oct-97	71	-	-
			MW4S-71.5	71.5
MW5I	19-Jun-98	96	-	-
MW6I	17-Jun-98	90	MW6-3	3
			MW6-5	5
MW7I	7-Jul-98	119	-	-
MW8I	8-Mar-99	129	-	-
PZ1	3-Mar-99	102.5	-	-
PZ2	2-Mar-99	48.5	-	-
PZ3	3-Mar-99	72	-	-
BP-01	29-Jul-90	6	BP-01-0-1	1
			BP-01-1-2	2
			BP-01-5-6	6
BP-02	29-Jul-90	6	BP-02-0-1	1
			BP-02-1-2	2
			BP-02-5-6	6
BP-03	28-Jul-90	6	BP-03-0-1	1
			BP-03-5-6	6
BP-04	28-Jul-90	6	BP-04-0-1	1
			BP-04-5-6	6
BP-05	27-Jul-90	6	BP-05-0-1	1
			BP-05-5-6	6

¹ Base of sampled interval
ft bgs - Feet below ground surface

TABLE 2

SUMMARY OF SOIL BORING PROGRAM



4120 Buckingham Place
Omaha, Nebraska

Soil Boring Number	Date Drilled	Termination Depth (ft bgs)	Sample Identification Number	Sample Depth ¹ (ft bgs)
BP-06	27-Jul-90	6	BP-06-0-0.4	0.4
			BP-06-0.5-1.5	1.5
			BP-06-5-6	6
BP-07	26-Jul-90	6	BP-07-0-0.3	0.3
			BP-07-0.5-1.5	1.5
			BP-07-5-6	6
BP-08	26-Jul-90	6	BP-08-0-1	1
			BP-08-5-6	6
BP-09	27-Jul-90	10	BP-09-0-1	1
			BP-09-4-5	5
			BP-09-9-10	10
BP-10	22-Jul-90	0.4	BP-10-0-0.4	0.4
BP-11	27-Jul-90	50	BP-11-0-0.4	0.4
			BP-11-0.5-1.5	1.5
			BP-11-4-5	5
			BP-11-9-10	10
			BP-11-14-15	15
			BP-11-19-20	20
			BP-11-24-25	25
			BP-11-29-30	30
			BP-11-34-35	35
			BP-11-39-40	40
			BP-11-44-45	45
			BP-11-49-50	50
BP-12	28-Jul-90	0.7	BP-12-0-0.7	0.7
BP-13	28-Jul-90	55	BP-13-0-1	1
			BP-13-0.5-1.5	1.5
			BP-13-4-5	5
			BP-13-9-10	10
			BP-13-14-15	15
			BP-13-19-20	20
			BP-13-24-25	25
			BP-13-34-35	35
			BP-13-44-45	45
BP-14	29-Jul-90	65	BP-14-0-1	1

¹ Base of sampled interval
ft bgs - Feet below ground surface

TABLE 2

SUMMARY OF SOIL BORING PROGRAM



4120 Buckingham Place
Omaha, Nebraska

Soil Boring Number	Date Drilled	Termination Depth (ft bgs)	Sample Identification Number	Sample Depth ¹ (ft bgs)
			BP-14-1.6-2.6	2.6
			BP-14-4-5	5
			BP-14-14-15	15
			BP-14-24-25	25
			BP-14-34-35	35
			BP-14-44-45	45
			BP-14-54-55	55
			BP-14-64-65	65
BP-15	22-Jul-90	0.3	BP-15-0-0.3	0.3
BP-16	28-Jul-90	10	BP-16-0-1	1
			BP-16-4-5	5
			BP-16-9-10	10
BP-17	28-Jul-90	10.5	BP-17-4-4.5	4.5
			BP-17-9-9.5	9.5

¹ Base of sampled interval
ft bgs - Feet below ground surface

TABLE 3
HYDROLOGIC TEST PARAMETERS

4120 Buckingham Place
Omaha, Nebraska

Measurement	Method
Moisture Content	ASTM D 2216-92
Bulk Density	ASTM D 2937-94, Klute, 1986. Chp. 13, pp. 363-367
Calculated Porosity	Klute, 1986, Chp. 8, pp. 444-445
Hydraulic Conductivity (Saturated): Constant head Falling head	ASTM D 2434-68(74) ASTM D 422-63 (90)
Hydraulic Conductivity (Unsaturated)	Van Genuchten, 1980
Particle Size Analysis: Sieve Hydraulic	ASTM D 2434-68 (74) Klute, 1986. Chp. 28, pp. 700-703
Cation Exchange Capacity	USDA No. 60 (19)
Total Organic Carbon	ASTM D 4129

TABLE 4



DRILLING METHODOLOGIES

4120 Buckingham Place
Omaha, Nebraska

oring Identificatio Number	Date Finished	Drilling Method
BSS1	22-Apr-97	Direct-Push Sampler
BSS2	22-Apr-97	Direct-Push Sampler
BSS3	22-Apr-97	Direct-Push Sampler
BSS4	8-Jun-97	Direct-Push Sampler/Hollow-Stem Auger
BSS5	22-Apr-97	Direct-Push Sampler
BSS6	22-Apr-97	Direct-Push Sampler
BSS7	22-Apr-97	Direct-Push Sampler
BSS8	8-Jun-97	Direct-Push Sampler/Hollow-Stem Auger
BSS9	22-Apr-97	Direct-Push Sampler
BSS10	22-Apr-97	Direct-Push Sampler
BSS11	23-Apr-97	Direct-Push Sampler
BSS12	23-Apr-97	Direct-Push Sampler
BSS13	23-Apr-97	Direct-Push Sampler
BSS14	23-Apr-97	Direct-Push Sampler
BSS15	23-Apr-97	Direct-Push Sampler
BSS16	23-Apr-97	Direct-Push Sampler
BSS17	24-Apr-97	Direct-Push Sampler
BSS18	6-Jun-97	Direct-Push Sampler/Hollow-Stem Auger
BSS19	24-Apr-97	Direct-Push Sampler
BSS20	24-Apr-97	Direct-Push Sampler
BSS21	8-Jun-97	Direct-Push Sampler/Hollow-Stem Auger
BSS22	24-Apr-97	Direct-Push Sampler
BSS23	24-Apr-97	Direct-Push Sampler
BSS24	24-Apr-97	Direct-Push Sampler
BSS25	24-Apr-97	Direct-Push Sampler
BSS26	5-Jun-97	Hollow-Stem Auger
BSS27	25-Apr-97	Direct-Push Sampler
BSS28	25-Apr-97	Direct-Push Sampler
BSS29	25-Apr-97	Direct-Push Sampler
BSS30	25-Apr-97	Direct-Push Sampler
BSS31	25-Apr-97	Direct-Push Sampler
BSS32	10-Jun-97	Hollow-Stem Auger
BSS33	11-Jun-97	Hollow-Stem Auger
BSS34	6-Oct-97	Direct-Push Sampler
BSS35	6-Oct-97	Direct-Push Sampler
BSS36	7-Oct-97	Direct-Push Sampler
BSS37	7-Oct-97	Direct-Push Sampler
BSS38	7-Oct-97	Direct-Push Sampler
BSS39	7-Oct-97	Direct-Push Sampler
BSS40	7-Oct-97	Direct-Push Sampler
BSS41	8-Oct-97	Direct-Push Sampler
BSS42	8-Oct-97	Direct-Push Sampler
BSS43	6-Oct-97	Direct-Push Sampler

TABLE 4



DRILLING METHODOLOGIES

4120 Buckingham Place
Omaha, Nebraska

oring Identificatio Number	Date Finished	Drilling Method
BSS44	8-Oct-97	Direct-Push Sampler
BSS45	8-Oct-97	Direct-Push Sampler
BSS46	8-Oct-97	Direct-Push Sampler
BSS47	8-Oct-97	Direct-Push Sampler
BSS48	8-Oct-97	Direct-Push Sampler
BSS49	8-Oct-97	Direct-Push Sampler
BSS50	8-Oct-97	Direct-Push Sampler
BSS51	30-Jun-98	Rotasonic
BSS52	28-Jun-98	Rotasonic
MW1I	22-Oct-97	Hollow-Stem Auger
MW2I	16-Oct-97	Hollow-Stem Auger
MW3I	20-Oct-97	Hollow-Stem Auger
MW4I	23-Oct-97	Hollow-Stem Auger
MW4S	29-Oct-97	Hollow-Stem Auger
MW5I	20-Jun-98	Rotasonic
MW6I	18-Jun-98	Rotasonic
MW7I	8-Jul-98	Rotasonic
MW8I	10-Mar-99	Rotasonic
PZ1	4-Mar-99	Hollow-Stem Auger
PZ2	2-Mar-99	Hollow-Stem Auger
PZ3	4-Mar-99	Hollow-Stem Auger
BP-01	29-Jul-90	Power Hand Auger
BP-02	29-Jul-90	Power Hand Auger
BP-03	28-Jul-90	Power Hand Auger
BP-04	28-Jul-90	Power Hand Auger
BP-05	27-Jul-90	Power Hand Auger
BP-06	27-Jul-90	Power Hand Auger
BP-07	26-Jul-90	Power Hand Auger
BP-08	26-Jul-90	Power Hand Auger
BP-09	27-Jul-90	Power Hand Auger
BP-10	22-Jul-90	Power Hand Auger
BP-11	27-Jul-90	Power Hand Auger
BP-12	28-Jul-90	Power Hand Auger
BP-13	28-Jul-90	Power Hand Auger
BP-14	29-Jul-90	Power Hand Auger
BP-15	22-Jul-90	Power Hand Auger
BP-16	28-Jul-90	Power Hand Auger
BP-17	28-Jul-90	Power Hand Auger

TABLE 5

SURVEY DATA

4120 Buckingham Place
Omaha, Nebraska

Measuring Point	Northing ¹ (feet)	Easting ¹ (feet)	Ground Surface Elevation (feet above NGVD)	Top of Casing Elevation (feet above NGVD)
BSS1	4324.35	5322.85	1142.0	NA
BSS2	4345.45	5334.37	1142.0	NA
BSS3	4357.83	5307.35	1141.8	NA
BSS4	4399.29	5279.66	1137.8	NA
BSS5	4431.28	5306.12	1138.5	NA
BSS6	4415.66	5260.57	1137.4	NA
BSS7	4439.72	5262.56	1137.5	NA
BSS8	4471.75	5263.73	1138.0	NA
BSS9	4530.93	5269.75	1141.8	NA
BSS10	4494.75	5237.81	1137.8	NA
BSS11	4527.02	5223.19	1138.0	NA
BSS12	4406.90	5219.85	1135.6	NA
BSS13	4451.61	5200.82	1136.1	NA
BSS14	4573.70	5108.46	1136.9	NA
BSS15	4614.25	5102.39	1136.9	NA
BSS16	4602.66	5139.40	1137.6	NA
BSS17	4360.64	5357.20	1142.2	NA
BSS18	4302.16	5333.09	1138.6	NA
BSS19	4560.90	5208.53	1138.4	NA
BSS20	4362.23	5239.20	1135.2	NA
BSS21	4376.52	5193.47	1134.6	NA
BSS22	4440.50	5182.06	1134.9	NA
BSS23	4508.10	5175.50	1136.8	NA
BSS24	4556.36	5156.36	1137.1	NA
BSS25	4529.37	5104.00	1136.4	NA
BSS26	4605.03	5086.78	1136.4	NA
BSS27	4297.75	5381.25	1139.4	NA
BSS28	4251.03	5394.99	1139.4	NA
BSS29	4271.24	5343.59	1137.4	NA
BSS30	4565.66	5096.33	1136.4	NA
BSS31	4521.48	5136.88	1136.0	NA
BSS32	4461.30	5168.85	1135.3	NA
BSS33	4310.50	5212.87	1135.1	NA
BSS34	4428.52	5233.57	1132.0	NA
BSS35	4219.83	5208.66	1131.4	NA
BSS36	4270.38	5163.74	1131.0	NA
BSS37	4325.68	5144.74	1130.9	NA
BSS38	4377.88	5135.14	1131.4	NA
BSS39	4429.17	5117.60	1131.6	NA
BSS40	499.79	5097.59	1132.1	NA
BSS41	4553.75	5081.69	1132.1	NA

TABLE 5



SURVEY DATA

4120 Buckingham Place
Omaha, Nebraska

Measuring Point	Northing ¹ (feet)	Easting ¹ (feet)	Ground Surface Elevation (feet above NGVD)	Top of Casing Elevation (feet above NGVD)
BSS42	4597.13	5066.54	1133.0	NA
BSS43	4325.18	5142.56	1130.9	NA
BSS44	4349.35	5138.36	1131.2	NA
BSS45	4301.34	5151.16	1130.9	NA
BSS46	4359.70	5136.58	1131.3	NA
BSS47	4293.09	5155.22	1130.9	NA
BSS48	4369.17	5133.20	1131.1	NA
BSS49	4282.62	5157.97	1130.9	NA
BSS50	4345.63	5124.27	1130.9	NA
BSS51	4109.50	5734.30	1165.7	NA
BSS52	4022.00	5704.10	1167.5	NA
MW1I	4588.95	5100.52	1136.8	1138.62
MW2I	4286.44	5376.55	1138.7	1141.63
MW3I	4250.94	5207.23	1132.4	1134.79
MW4S	4478.12	5162.99	1135.3	1137.52
MW4I	4465.55	5156.15	1135.3	1137.65
MW5I	4547.97	5254.41	1140.1	1142.66
MW6I	4694.03	5070.35	1134.6	1137.27
MW7I	4114.10	5722.85	1164.6	1167.21
MW8I	3818.91	5636.42	1178.1	1181.47
PZ1 ²	5277.08	4673.36	1100.5	1100.52
PZ2 ²	4801.81	5045.53	1056.3	1056.27
PZ3 ²	4579.38	4308.80	1081.5	1083.94

¹ Measured relative to a coordinate system established on site.

² Northing and Easting coordinates for PZ1, PZ2, and PZ3 were measured from a separate coordinate system.

NGVD - National Geodetic Vertical Datum

TABLE 6

SUMMARY OF SOIL CHEMICAL ANALYSIS PROGRAM



4120 Buckingham Place
Omaha, Nebraska

Soil Boring Number	Sample Depth (feet bgs)	IVOC	VOC	SVOC	PEST	MET	PCB	DX	pH
BSS1	12	X							
BSS2	12	X							
BSS3	12	X							
BSS4	2								X
	10								X
	12	X							
	20	X	X	X	X	X	X		
BSS5	12	X							
BSS6	12	X							
BSS7	12	X							
BSS8	2								X
	10								X
	12	X							
	20	X	X	X	X	X	X		X
BSS9	12	X							
BSS10	12	X							
BSS11	12	X							
BSS12	12	X							
BSS13	12	X							
BSS14	12	X							
BSS15	12	X							
BSS16	12	X							
BSS17	12	X							
BSS18	2								X
	10								X
	12	X							
	20	X	X	X	X	X	X	X	X
	30	X	X	X	X	X	X		X
	40	X	X	X	X	X	X		X
	48		X	X	X	X	X		
	50	X							X
	60	X	X						X
	69	X							
	70		X						
	75	X							X
BSS19	12	X							
BSS20	12	X							
BSS21	2								X
	10								X
	12	X	X						
	20	X							
	21		X	X	X	X	X		
	30					X			X

X - Sample analyzed

TABLE 6

SUMMARY OF SOIL CHEMICAL ANALYSIS PROGRAM



4120 Buckingham Place
Omaha, Nebraska

Soil Boring Number	Sample Depth (feet bgs)	IVOC	VOC	SVOC	PEST	MET	PCB	DX	pH
	40								X
	50								X
	60								X
	63	X	X	X	X	X	X		X
	69	X							
BSS22	12	X							
BSS23	12	X							
BSS24	12	X							
BSS25	12	X							
BSS26	2								X
	10								X
	12	X							
	17.5	X	X	X	X	X	X		
	20								X
	30	X	X	X	X	X	X		X
	40	X	X	X	X	X	X		
	42								X
	50	X	X	X	X	X	X		X
	59	X	X						X
	69		X						X
	70	X							
	77	X	X						
BSS27	12	X							
BSS28	12	X							
BSS29	12	X							
BSS30	12	X							
BSS31	12	X							
BSS32	9	X	X	X	X	X	X	X	
	10								X
	20	X	X	X	X	X	X		X
	30	X							X
	30.5		X	X	X	X	X		
	40	X	X	X	X	X	X		X
	49	X	X	X	X	X	X		X
	59	X	X						X
BSS33	5.5		X	X	X	X	X		
	10	X	X	X	X	X	X		X
	20	X							X
	21		X	X	X	X	X		
	28.5	X	X	X	X	X	X		X
	40	X	X	X	X	X	X		X
	48	X	X	X	X	X	X		X
	60	X	X						

X - Sample analyzed

TABLE 6



SUMMARY OF SOIL CHEMICAL ANALYSIS PROGRAM

4120 Buckingham Place
Omaha, Nebraska

Soil Boring Number	Sample Depth (feet bgs)	IVOC	VOC	SVOC	PEST	MET	PCB	DX	pH
BSS34	2		X	X	X	X	X	X	
	10	X	X	X	X	X	X	X	
BSS35	2	X	X	X	X	X			
BSS36	2	X	X		X				
BSS37	2	X	X		X	X			
	10	X	X			X			
	20	X	X						
	30	X	X						
BSS38	2	X	X		X				
BSS39	2	X	X		X	X			
BSS40	2	X	X		X				
BSS41	2	X	X		X	X			
BSS42	2	X	X		X				
BSS43	2	X							
BSS44	2	X							
BSS45	2	X							
BSS46	2	X							
BSS47	2	X							
BSS48	2	X							
BSS49	2	X							
BSS50	2	X							
MW11	2		X	X	X	X			
	9		X	X	X	X			
	71		X						
	90		X						
MW21	2		X	X	X	X		X	
	10		X	X	X	X		X	
MW31	2.5		X	X	X	X			
	10		X	X	X	X			
MW41	5.5		X	X	X	X			
	10		X	X	X	X			
MW61	3			X					
	5			X					
BP1	1			X	X	X			
	2		X	X	X	X			
	6		X	X	X	X			
BP2	1			X	X	X			
	2		X	X	X	X			
	6		X	X	X	X			
BP3	6		X	X	X	X			
BP4	1			X	X	X			
	6		X	X	X	X			
BP5	1			X	X	X			

X - Sample analyzed

TABLE 6

SUMMARY OF SOIL CHEMICAL ANALYSIS PROGRAM



4120 Buckingham Place
Omaha, Nebraska

Soil Boring Number	Sample Depth (feet bgs)	IVOC	VOC	SVOC	PEST	MET	PCB	DX	pH
	6			X	X	X			
BP6	0.4			X	X	X			
	1.5		X	X	X	X			
	6		X	X	X	X			
BP7	0.3			X	X	X			
	1.5			X	X	X			
	6		X	X	X	X			
BP8	1			X	X	X			
	6		X	X	X	X			
BP9	1			X	X	X			
	5		X	X	X	X			
	10		X	X	X	X			
BP10	0.4			X	X	X			
BP11	0.4			X	X	X			
	1.5		X	X		X			
	5		X	X		X			
	10		X	X		X			
	15		X	X		X			
	20		X	X		X			
	25		X	X		X			
	30		X	X		X			
	35		X	X		X			
	40		X	X		X			
	45		X	X		X			
	50		X	X		X			
BP12	0.7			X	X	X			
BP13	1			X	X	X			
	1.5		X	X	X	X			
	5		X	X	X	X			
	10		X	X	X	X			
	15		X	X		X			
	20		X	X		X			
	25		X	X		X			
	35		X	X		X			
	45		X	X		X			
BP14	1			X	X	X			
	2.6		X	X	X	X			
	5		X	X	X	X			
	15		X	X		X			
	25		X	X		X			
	35		X	X		X			
	45		X	X		X			
	55		X	X		X			

X - Sample analyzed

TABLE 6



SUMMARY OF SOIL CHEMICAL ANALYSIS PROGRAM

4120 Buckingham Place
Omaha, Nebraska

Soil Boring Number	Sample Depth (feet bgs)	IVOC	VOC	SVOC	PEST	MET	PCB	DX	pH
	65		X	X		X			
BP15	0.3			X	X	X			
BP16	1			X					
	5		X	X					
	10		X	X					
BP17	0.5			X					
	4.5		X	X					
	9.5		X	X					

bgs - Below ground surface

IVOC - Indicator parameters analyzed on-site

VOC - Volatile organic compounds on constituents of potential concern (COPC) list

SVOC - Semivolatile organic compounds on COPC list

PEST - Pesticides on COPC list

MET - Metals on COPC list

PCB - Polychlorinated biphenyls on COPC list

DX - Dioxins on COPC list

X - Sample analyzed

HYDROLOGIC TESTING PROGRAM

4120 Buckingham Place
Omaha, Nebraska

Stratigraphic Unit	Sample Number ¹	Moisture Content ² (%)	Bulk Density ³ (g/cm ³)	Calculated Porosity (%)	K _{sat} (cm/sec)	K _{unsat} ⁴ (cm/sec)	Hazen's K ⁵ (cm/sec)	Particle Size Characteristics		CEC (meq/100g)	TOC (mg/kg)
								d ₁₀ (mm)	d ₅₀ (mm)		
Loess	SS8-12	X	X	X	X	X		X	X	X	X
Loess	SS2-27	X	X	X	X	X		X	X	X	X
Loess	BSS18-27	X	X	X	X	X		X	X	X	X
Loess	BSS26-47	X	X	X	X	X		X	X	X	X
Loess	BSS21-52	X	X	X	X	X		X	X	X	X
Loess	SS6-53	X	X	X	X	X		X	X	X	X
S Stratified	SS2-47	X	X	X	X	X		X	X	X	X
S Stratified	SS8-59							X	X		
S Stratified	BSS18-64	X	X	X	X	X		X	X	X	X
S Stratified	BSS18-69							X	X		
S Stratified	SS8-70	X	X	X	X	X		X	X	X	X
S Stratified	MW4S-71.5							X	X		
S Stratified	SS2-56	X	X	X	X	X		X	X	X	X
S Stratified	SS6-69	X	X	X	X	X		X	X	X	X
S Stratified	BSS26-77							X	X		
I Sand	MW3-75						X	X	X		
I Sand	SS8-75						X	X	X		
I Sand	BSS21-77						X	X	X		
I Sand	SS6-78						X	X	X		

HYDROLOGIC TESTING PROGRAM

4120 Buckingham Place
Omaha, Nebraska

Stratigraphic Unit	Sample Number ¹	Moisture Content ² (%)	Bulk Density ³ (g/cm ³)	Calculated Porosity (%)	K _{sat} (cm/sec)	K _{unsat} ⁴ (cm/sec)	Hazen's K ⁵ (cm/sec)	Particle Size Characteristics		CEC (meq/100g)	TOC (mg/kg)
								d ₁₀ (mm)	d ₅₀ (mm)		
I Sand	MW4D-80						X	X	X		
I Sand	MW1-82						X	X	X		
I Sand	MW2-87						X	X	X		
I Sand	BSS52-120		X				X	X	X		X
I Till	BSS52-132							X	X		X

¹By ascending depth²Volumetric moisture content, cm³/cm³³Wet bulk density⁴K value calculated using volumetric moisture content of sample.⁵K = C(d₁₀)² where C = 1

CEC Cation Exchange Capacity

TOC Total Organic Carbon

g/cm³ grams per cubic centimeter

cm/sec centimeter per second

mm millimeters

meq/100g milliequivalents per 100 grams

mg/kg milligrams per kilogram

K hydraulic conductivity

d₁₀ effective grain size (10% of particles are finer)d₅₀ mean grain size (50% of particles are finer)K_{sat} saturated conductivityK_{unsat} unsaturated conductivity

TABLE 8
SOIL CHEMICAL ANALYTICAL METHODS

4120 Buckingham Place
Omaha, Nebraska

Analysis	U.S.EPA Method
Volatile Organic Compounds	8240B
Indicator Volatile Organic Compounds	8010 / 8020 modified
Semivolatile Organic Compounds	8270B
Cyanide	9010 / 9012
Metals	6010 / 7471
Pesticides	8080A
Polychlorinated Biphenyls	8080A
Dioxins	8290

SUMMARY OF SOIL QUALITY ASSURANCE/QUALITY CONTROL SAMPLES

4120 Buckingham Place
Omaha, Nebraska

QA/QC Sample Identification	Date Collected	Sample Type	IVOC	VOC	SVOC	MET	PEST	CY	DX	PCB	pH	Associated Investigative Sample
CS-BSS11	4/23/97	Duplicate	X	X								BSS11-10-12
CSBSS31	4/25/97	Duplicate	X	X								BSS31-10-12
BSS21-63 Dup	6/1/97	Duplicate	X									BSS21-63
BSS31-60 Dup	6/1/97	Duplicate	X									BSS31-60
Dup-BSS18-75	6/6/97	Duplicate									X	BSS18-75
CS-BSS8-20	6/8/97	Duplicate	X	X								BSS8-20
BSSD1	6/10/97	Duplicate		X	X	X	X	X	X			BSS32-40
BSSD2	6/10/97	Duplicate		X								BSS33-21
BSSD3	6/10/97	Duplicate			X	X	X	X		X		BSS33-48
Dup-BSS33-48	6/10/97	Duplicate									X	BSS33-48
CSBSS32-30	6/10/97	Duplicate	X	X								BSS32-30
BSS44-2 Dup	11/1/97	Duplicate	X									BSS44-2
BSSD4	10/7/97	Duplicate		X		X	X			X		BSS39-2
BSSD5	10/16/97	Duplicate		X	X	X	X	X	X			MW3-2.5
B-FB1	6/10/97	Field Blank		X	X	X	X		X	X		
B-FB2	10/8/97	Field Blank		X	X	X	X			X		
B-EB1	6/10/97	Equipment Blank		X	X	X	X		X	X		
B-EB2	10/7/97	Equipment Blank		X	X	X	X		X	X		
B-EB3	10/21/97	Equipment Blank		X	X	X	X			X		
MS/MDS-BSS21-12	6/8/97	Matrix Spike/Matrix Duplicate Spike		X								
MSD-BSS36-2	10/7/97	Matrix Spike/Matrix Duplicate Spike		X			X			X		
B-PE1	10/8/97	Performance Evaluation				X						

Notes:

VOC - Volatile organic compounds

SVOC - Semivolatile organic compounds

MET - Metals

DX - Dioxins

IVOC - Volatile organic compounds used as indicator parameters

CY - Cyanide

PEST - Pesticides

PCB - Polychlorinated Biphenyls

MONITORING WELL AND PIEZOMETER CONSTRUCTION DETAILS

4120 Buckingham Place
Omaha, Nebraska

Monitoring Well Identification Number	Ground Surface Elevation (feet NGVD)	Northing Coordinate ¹ (feet)	Easting Coordinate ¹ (feet)	Top of Casing Elevation (feet NGVD)	Approximate Total Depth ² (feet)	Well Screen Length (feet)	Approximate Top of Screen Elevation (feet)	Approximate Bottom of Screen Elevation (feet)
MW11	1136.8	4588.9512	5100.5210	1138.62	90.0	10	1056.8	1046.8
MW21	1138.7	4286.4350	5376.5531	1141.63	89.0	10	1059.7	1049.7
MW31	1132.4	4250.9395	5207.2311	1134.79	88.0	10	1054.4	1044.4
MW41	1135.3	4465.5500	5156.1466	1137.65	89.5	10	1055.8	1045.8
MW4S	1135.3	4478.1221	5162.9877	1137.52	71.0	10	1074.3	1064.3
MW51	1140.1	4547.9700	5254.4100	1142.66	96.0	10	1054.1	1044.1
MW61	1134.6	4694.0300	5070.3500	1137.27	90.0	10	1054.6	1044.6
MW71	1164.6	4114.1000	5722.8500	1167.21	119.0	10	1055.6	1045.6
MW81	1178.1	3818.9100	5636.4200	1181.47	129.0	10	1059.1	1049.1
PZ1	1098.2	5277.0800	4673.3600	1100.52	102.5	10	1005.7	995.7
PZ2	1053.9	4801.8100	5045.5300	1056.27	48.5	10	1015.4	1005.4
PZ3	1081.5	4579.3800	4308.8000	1083.94	72.0	10	1019.5	1009.5

¹ Relative to facility coordinate system established by Ehrhart Griffin & Associates of Omaha, Nebraska, except PZ1, PZ2, and PZ3 which are relative to local system.

² Measured from ground surface

NGVD - National Geodetic Vertical Datum

TABLE 11

SUMMARY OF GROUNDWATER CHEMICAL ANALYSIS PROGRAM



4120 Buckingham Place
Omaha, Nebraska

WELL IDENTIFICATION NUMBER	SAMPLE DATE	VOC	SVOC	PEST	MET	IONS	TOC	DISSOLVED GASES
MW1I	11/11/97	X	X	X	X			
	1/13/98	X	X	X	X			
	7/14/98	X				X	X	X
	9/1/98	X						
	12/15/98	X		X				
	3/6/99	X						X
MW2I	11/11/97	X	X	X	X			
	1/14/98	X	X	X	X			
	7/15/98	X				X	X	X
	9/2/98	X						
	12/15/98	X		X				
	3/7/99	X						X
MW3I	11/12/97	X	X	X	X			
	1/14/98	X	X	X	X			
	7/15/98	X				X	X	X
	9/2/98	X						
	12/15/98	X		X				
	3/7/99	X						X
MW4I	11/11/97	X	X	X	X			
	1/14/98	X	X	X	X			
	7/15/98	X				X	X	X
	9/2/98	X						
	12/15/98	X		X				
	3/7/99	X						X
MW4S	11/12/97	X	X	X	X			
	1/14/98	X	X	X	X			
	7/14/98	X				X	X	X
	9/1/98	X						
	12/14/98	X		X				
	3/9/99	X						X
MW5I	7/14/98	X				X	X	X
	9/1/98	X						
	12/15/98	X		X				
	3/6/99	X						X
MW6I	7/14/98	X				X	X	X
	9/1/98	X						
	12/14/98	X		X				
	3/6/99	X						X
MW7I	7/15/98	X				X	X	X
	9/2/98	X						
	12/15/98	X		X				
	3/7/99	X						X
MW8I	3/24/99	X						X
PZ1	3/7/99	X				X	X	X
PZ2	3/6/99	X				X	X	X
PZ3	3/7/99	X				X	X	X

VOC - Volatile organic compounds on constituent of potential concern (COPC) list

Dissolved Gases - Methane, ethane, ethene, propane

IONS - Chloride, sulfate and nitrate

TOC - Total organic carbon

SVOC - Semivolatiles on COPC list

PEST - Pesticides on COPC list

TABLE 12
GROUNDWATER ANALYTICAL METHODS

4120 Buckingham Place
Omaha, Nebraska

Analysis	U.S.EPA Method
Chloride	300.0
Methane, Ethane, Ethene, Propane	Risk Method 175
Nitrate	300.0
Sulfate	300.0
Total Organic Carbon	415.1
Volatile Organic Compounds	8260A / 8021
Semivolatile Organic Compounds	8270B
Total Metals	6010A / 7060A / 7421 / 7470A / 7841
Pesticides	8080A

SUMMARY OF GROUNDWATER QUALITY ASSURANCE/QUALITY CONTROL SAMPLES

4120 Buckingham Place

Omaha, Nebraska

QA/QC Sample Identification	Date Collected	Sample Type	IVOC	VOC	SVOC	MET	PEST	METH	IONS	TOC	Associated Investigative Sample
BSSDW	11/11/97	Duplicate		X	X	X	X				MW4D
BSSW2	1/14/98	Duplicate		X	X	X	X				MW2_011498
DUP	7/29/98	Duplicate		X							BSS51-105
DUP_071598	7/14/98	Duplicate		X				X	X	X	MW4I_071598
DUP_090298	9/2/98	Duplicate		X							MW7I_090298
DUP_121598	12/15/98	Duplicate		X							MW2I_121598
DUP_030799	3/7/99	Duplicate		X				X	X	X	MW3I_030799
B-FB5	1/14/98	Field Blank		X							
Field Blank	6/27/98	Field Blank		X							
B-EB4	11/12/97	Equipment Blank		X	X	X	X				
B-EB5	1/13/98	Equipment Blank		X			X				
B-EB6	1/14/98	Equipment Blank		X			X				
EB_071498	7/14/98	Equipment Blank		X							
EB_071598	7/15/98	Equipment Blank		X							
EB_090198	9/1/98	Equipment Blank		X							
EB_090298	9/2/98	Equipment Blank		X							
EB_121598	12/15/98	Equipment Blank		X							
EB_030699	3/6/99	Equipment Blank		X							
EB_030799	3/7/99	Equipment Blank		X							
MSDMW1	11/11/97	Matrix Spike/Matrix Duplicate Spike		X	X	X	X				
BSSSP-2	11/11/97	Performance Evaluation		X							
BSS SP-1	11/17/97	Performance Evaluation				X					

Notes:

VOC - Volatile organic compounds

IVOC - Volatile organic compounds used as indicator parameters

SVOC - Semivolatile organic compounds

CY - Cyanide

MET - Metals

METH - Methane

IONS - Chloride, Sulfate, Nitrate

TOC - Total Organic Carbons

TABLE 14

COC FATE AND TRANSPORT PARAMETER VALUES

4120 Buckingham Place
Omaha, Nebraska

Parameter	Value	Basis
Horizontal groundwater velocity	200 feet per year	Site data
Longitudinal dispersivity (alpha x)	50 feet	Xu and Eckstein, 1995
Transverse dispersivity (alpha y)	5 feet	10% of alpha x
Vertical dispersivity (alpha z)	0 feet	Set to 0 as conservative factor
Hydraulic conductivity (K)	0.034 cm/sec	Site data
Hydraulic gradient (i)	0.002	Site data
Effective porosity (n)	0.35	Site data
Partition coefficient (K _{oc})	126 l/kg	Pankow and Cherry, 1996
Organic carbon (f _{oc})	0.00048	Site data
Bulk density	2.6 kg/l	Site data

The horizontal groundwater velocity was calculated using Darcy's Law as given below:

$$v_{gw} = \frac{Ki}{n}$$

where K is the horizontal hydraulic conductivity, i is the horizontal hydraulic gradient, and n is the effective porosity of the porous medium.

The retardation of constituent migration in groundwater via adsorption is directly proportional to the amount of naturally occurring organic carbon in the porous media. The retardation factor was calculated using the formula given below:

$$R_f = v_{gw}/v_c = 1 + K_p(\rho_b)/n$$

where v_{gw} is the horizontal groundwater velocity, v_c is the velocity of the constituent of interest, K_p is the partitioning coefficient, ρ_b is the bulk density of the porous material, and n is the effective porosity.

The equation used to estimate the partitioning coefficient is as follows:

$$K_p = K_{oc}f_{oc}$$

where K_{oc} is the partition coefficient of the constituent on organic carbon, and f_{oc} is the fraction of organic carbon in the soil.

TABLE 15

HYDROSTRATIGRAPHIC COLUMN

4120 Buckingham Place
Omaha, Nebraska

Lithology	Nomenclature in this Report	Approximate Top of Unit Elevation at Facility ¹	Approximate Top of Unit Elevation at PZ3 ^{1, 2}
Clayey Silt, Silt	Loess	Ground Surface (~1135)	Ground Surface (1080)
Stratified Silt with Sand, Sandy Silt, Silty Sand, and Sand	S Stratified Unit	1080	Not Present
Silty Clay with Sand, Sandy Lean Clay	S Till Unit	1070	Not Present
Poorly Graded Sand	I Sand Unit	1060	1033
Sandy Lean Clay, Lean Clay with Sand, Lean Clay	I Till Unit	1040	1010

1. Feet relative to NGVD

2. PZ3 was located approximately 1 mile east - southeast of the facility.

SUMMARY OF HYDROLOGIC TESTING DATA

4120 Buckingham Place
Omaha, Nebraska

Stratigraphic Unit	Sample Number ¹	Moisture Content ² (%)	Bulk Density ³ (g/cm ³)	Calculated Porosity (%)	K _{sat} (cm/sec)	K _{unsat} ⁴ (cm/sec)	Hazen's K ⁵ (cm/sec)	Particle Size Characteristics		CEC (meq/100g)	TOC (mg/kg)
								d ₁₀ (mm)	d ₅₀ (mm)		
Loess	SS8-12	35.7	1.83	44.5	2.70E-06	1.30E-09	NM	5.40E-06	0.021	9.15	1830
Loess	SS2-27	32.7	1.99	37.1	5.10E-08	2.50E-08	NM	3.20E-06	0.018	7.83	1160
Loess	BSS18-27	37	1.96	39.9	7.00E-07	1.00E-08	NM	0.0011	0.024	11.1	560
Loess	BSS26-47	36.4	2	38.3	4.00E-07	1.00E-09	NM	4.10E-08	0.013	11.3	930
Loess	BSS21-52	30.8	2.04	34.5	2.10E-07	1.00E-10	NM	2.80E-05	0.018	8.54	740
Loess	SS6-53	39	1.92	42.4	7.40E-08	9.00E-09	NM	7.20E-07	0.017	9.11	1480
S Stratified	SS2-47	34.7	2.03	36.4	2.20E-08	1.30E-12	NM	2.40E-05	0.015	8.5	360
S Stratified	SS8-59	NM	NM	NM	NM	NM	NM	2.20E-07	0.026	NM	NM
S Stratified	BSS18-64	28.5	2.07	32.8	2.80E-08	1.00E-09	NM	1.70E-06	0.037	11.2	410
S Stratified	BSS18-69	NM	NM	NM	NM	NM	NM	3.70E-05	0.054	NM	NM
S Stratified	SS8-70	28.9	2.11	31.4	1.70E-08	1.50E-11	NM	6.90E-06	0.02	9.94	420
S Stratified	MW4S-71.5	NM	NM	NM	NM	NM	NM	2.40E-03	0.47	NM	NM
S Stratified	SS2-56	36.6	2.01	37.9	4.70E-08	9.00E-12	NM	1.70E-06	0.0092	9.6	340
S Stratified	SS6-69	38	2.02	38.3	3.70E-07	1.00E-11	NM	2.30E-05	0.0092	9.39	940
S Stratified	BSS26-77	NM	NM	NM	NM	NM	NM	9.00E-08	0.045	NM	NM
I Sand	MW3-75	NM	NM	NM	NM	NM	6.8E-02	0.26	0.55	NM	NM
I Sand	SS8-75	NM	NM	NM	NM	NM	2.6E-02	0.16	0.38	NM	NM
I Sand	BSS21-77	NM	NM	NM	NM	NM	3.6E-02	0.19	0.37	NM	NM
I Sand	SS6-78	NM	NM	NM	NM	NM	2.6E-02	0.16	0.43	NM	NM

SUMMARY OF HYDROLOGIC TESTING DATA

4120 Buckingham Place
Omaha, Nebraska

Stratigraphic Unit	Sample Number ¹	Moisture Content ² (%)	Bulk Density ³ (g/cm ³)	Calculated Porosity (%)	K _{sat} (cm/sec)	K _{unsat} ⁴ (cm/sec)	Hazen's K ⁵ (cm/sec)	Particle Size Characteristics		CEC (meq/100g)	TOC (mg/kg)
								d ₁₀ (mm)	d ₅₀ (mm)		
I Sand	MW4D-80	NM	NM	NM	NM	NM	3.2E-02	0.18	0.39	NM	NM
I Sand	MW1-82	NM	NM	NM	NM	NM	1.4E-02	0.12	0.26	NM	NM
I Sand	MW2-87	NM	NM	NM	NM	NM	2.9E-02	0.17	0.59	NM	NM
I Sand	BSS52-120	NM	2.64	NM	NM	NM	7.30E-02	0.27	0.62	NM	480
I Till	BSS52-132	NM	NM	NM	NM	NM	NM	2.80E-04	0.015	NM	14400

¹By ascending depth

²Volumetric moisture content, cm³/cm³

³Wet bulk density

⁴K value calculated using volumetric moisture content of sample.

⁵K = C(d₁₀)² where C = 1

NM Not Measured

CEC Cation Exchange Capacity

TOC Total Organic Carbon

g/cm³ grams per cubic centimeter

cm/sec centimeter per second

mm millimeters

meq/100g milliequivalents per 100 grams

mg/kg milligrams per kilogram

K hydraulic conductivity

d₁₀ effective grain size (10% are finer)

d₅₀ mean grain size (50% are finer)

GROUNDWATER ELEVATION MEASUREMENTS

4120 Buckingham Place
Omaha, Nebraska

Monitoring Well	MP ELEV	GW Elev 11/11/97	GW Elev 11/13/97	GW Elev 1/13/98	GW Elev 2/13/98	GW Elev 4/9/98	GW Elev 4/30/98	GW Elev 5/20/98	GW Elev 6/16/98	GW Elev 7/13/98	GW Elev 8/20/98
MW1I	1138.62	1068.33	1068.80	1068.16	1068.62	1069.09	1069.77	1069.59	1070.94	1072.13	1071.92
MW2I	1141.63	1067.69	1068.23	1067.61	1068.04	1068.50	1069.13	1068.97	1070.23	1071.35	1071.20
MW3I	1134.79	1067.95	1068.40	1067.76	1068.22	1068.68	1069.32	1069.16	1070.53	1071.63	1071.44
MW4I	1137.65	1068.09	1068.55	1067.92	1068.37	1068.85	1069.51	1069.34	1070.70	1071.85	1071.67
MW4S	1137.52		1069.39	1068.71	1069.11	1069.56	1070.34	1070.17	1071.66	1072.97	1072.82
MW5I	1142.66									1071.77	1071.60
MW6I	1137.27									1072.27	1072.06
MW7I	1167.21									1070.35	1070.26
MW8I	1181.47										
PZ1	1100.52										
PZ2	1056.27										
PZ3	1083.94										

Monitoring Well	MP ELEV	GW Elev 9/1/98	GW Elev 10/9/98	GW Elev 11/26/98	GW Elev 12/14/98	GW Elev 2/4/99	GW Elev 3/5/99	GW Elev 3/9/99	GW Elev 3/10/99	GW Elev 3/24/99
MW1I	1138.62	1072.06	1071.54	1071.36	1070.65	1070.16	1070.00	1069.94	nm	1069.80
MW2I	1141.63	1071.34	1070.88	1070.74	1070.04	1069.57	1069.41	1069.36	nm	1069.22
MW3I	1134.79	1071.59	1071.09	1070.93	1070.23	1069.74	1069.59	1069.54	nm	1069.39
MW4I	1137.65	1071.80	1071.28	1071.12	1070.41	1069.93	1069.76	1069.71	nm	1069.57
MW4S	1137.52	1072.98	1072.46	1072.38	1071.86	1071.35	1071.26	1070.70	nm	1070.60
MW5I	1142.66	1071.73	1071.25	1071.10	1070.38	1069.92	1069.75	1069.69	nm	1069.55
MW6I	1137.27	1072.19	1071.68	1071.50	1070.77	1070.31	1070.12	1070.05	nm	1069.92
MW7I	1167.21	1070.40	1070.01	1069.90	1069.23	1068.81	1068.65	1068.64	nm	1068.49
MW8I	1181.47								nm	1068.30
PZ1	1100.52						1020.96	1020.94	1020.94	
PZ2	1056.27						1020.49	1020.49	1020.49	
PZ3	1083.94						1020.06	1020.07	1020.08	

MP Elev - Measuring point elevation relative to the national vertical geodetic datum in feet

GW Elev - Groundwater elevation calculated to the NGVD in feet

NM - Not measured

TABLE 18
SUMMARY OF CLIMATIC DATA

4120 Buckingham Place
Omaha, Nebraska

	Temperature ¹ (°F)			Precipitation ² (in)			Wind Speed ³ (mph)		Relative Humidity ⁴ (%)		Evaporation ⁵ (in)	Atmospheric Pressure ⁶ (mB)
	Avg	Min	Max	Avg	Min	Max	Avg	Direction	0600 CST	1200 CST	Pan	Avg
January	21.1	10.9	31.3	0.74	T	3.70	10.9	NNW	78	66	NA	983.0
February	26.9	16.7	37.1	0.77	0.09	2.97	11.1	NNW	79	63	NA	983.8
March	38.6	27.7	49.4	2.04	0.12	5.96	12.3	NNW	79	57	NA	979.5
April	51.9	39.9	63.8	2.66	0.23	6.45	12.6	NNW	77	52	NA	978.3
May	62.4	50.9	74.0	4.52	0.56	10.33	10.9	SSE	81	54	NA	978.1
June	72.1	60.4	83.7	3.87	1.03	10.81	10.1	SSE	83	56	NA	977.7
July	76.9	65.9	87.9	3.51	0.39	10.34	8.8	SSE	85	58	NA	979.2
August	74.1	62.9	85.2	3.24	0.61	10.16	8.8	SSE	87	59	NA	980.4
September	65.1	53.6	76.5	3.72	0.41	13.75	9.4	SSE	87	59	NA	981.1
October	53.4	41.2	65.6	2.28	T	4.99	9.8	SSE	82	55	NA	982.0
November	39.0	28.7	49.3	1.49	0.03	4.70	10.9	SSE	81	62	NA	981.3
December	25.1	15.6	34.6	1.02	T	5.42	10.7	SSE	81	68	NA	983.4
Annual	50.6	39.5	61.5	29.86	T	13.75	10.5	SSE	82	59	58	980.6

Period of record is 1961 through 1990, except for prevailing wind direction (measured through 1963) and pan evaporation (1946 to 1955).

Avg	Average	mB	milliBars	Min	Minimum
Max	Maximum	in	inches	mph	miles per hour
CST	Central Standard Time	NA	Not Applicable	T	Trace
°F	Degrees Fahrenheit				

¹ Source: <http://www.ncdc.noaa.gov/rcsg/ccd/mintemp.htm>; <http://www.ncdc.noaa.gov/rcsg/ccd/maxtemp.htm>;
<http://www.ncdc.noaa.gov/rcsg/ccd/meantemp.htm>, downloaded 8/20/97.

² Source: <http://www.ncdc.noaa.gov/rcsg/ccd/nrmlprcp.htm>, downloaded 8/20/97; Normals, Means, and Extremes, Omaha (Eppley Airfield) Nebraska.

³ Source: <http://www.ncdc.noaa.gov/rcsg/ccd/avgwind.htm>, downloaded 8/20/97; Normals, Means, and Extremes, Omaha (Eppley Airfield) Nebraska.

⁴ Source: <http://www.ncdc.noaa.gov/rcsg/ccd/avgrh.htm>; downloaded 8/20/97.

⁵ Source: U.S. Department of Commerce, 1962.

TABLE 19



SUMMARY OF DETECTED METALS CONCENTRATIONS

4120 Buckingham Place
Omaha, Nebraska

Concentrations are reported in milligrams per kilogram (mg/kg)

Metal	Detected Concentrations			Adjacent Facility Mean ¹	Native Soils ²	
	Minimum	Maximum	Mean		Mean	Range
Aluminum	3,690.0	17,000	10,963	9,853	33,000	7,000 - >100,000
Antimony	-- Not detected --			Not detected	0.52	< 1 - 8.8
Arsenic	3.3	13	5.8	5.7	4.8	< 0.1 - 73
Barium	13.0	339	156	187	290	10 - 1,500
Beryllium	0.26	2.7	0.82	0.72	0.55	< 1 - 7
Cadmium	2	2	2 ³	Not analyzed	None reported	None reported
Calcium	2,360	11,700	4,138	Not analyzed	3,400	100 - 280,000
Chromium	6.00	32.0	13.5	11.9	33	1 - 1,000
Cobalt	3.5	16	8.6	7.9	5.9	< 0.3 - 70
Copper	11	76	18	16	13	< 1 - 700
Iron	646.00	59,900	14,200	12,275	14,000	100 - >100,000
Lead	1.30	829	16.8	19.6	14	< 10 - 300
Magnesium	549.0	8,510	3,602	Not analyzed	2,100	50 - 50,000
Manganese	33.0	1,470	415	413	260	< 2 - 7,000
Mercury	0.047	0.24	0.11 ³	0.047	0.081	0.01 - 3.4
Nickel	4.30	32.0	17.9	19.7	11	< 5 - 700
Potassium ⁴	1,260	2,400	1,729	Not analyzed	12,000	50 - 37,000
Selenium	0.75	1.2	0.94	0.75	0.30	< 0.1 - 3.9
Sodium	68.0	1,160	344	Not analyzed	2,500	< 500 - 50,000
Thallium	-- Not detected --			Not detected	7.7	2.2 - 23
Vanadium	16.8	49.0	26.6	24.1	43	< 7 - 300
Zinc	33.0	430	57.8	74.2	40	< 5 - 2,900

Means are geometric in accordance with Shacklette and Boerngen, 1984.

¹ Source: Geomatrix, 1998.

² Source: Shacklette and Boerngen, 1984; concentrations from eastern United States
(east of 96th meridian)

³ There were three detections for cadmium, two for mercury.

⁴ The mean for native soils is arithmetic for potassium (Shacklette and Boerngen, 1984).

TABLE 20

SUMMARY OF GROUNDWATER VOLATILE ORGANIC COMPOUND CONCENTRATIONS

4120 Buckingham Place

Omaha, Nebraska



Well	Date	Carbon Tetrachloride ug/l	Chloroform ug/l	1,1-Dichloroethane ug/l	1,1-Dichloroethene ug/l	cis-1,2-Dichloroethene ug/l
MW4S	11/12/97	61	120	360	2100	1400
	1/14/98	54 J	91 J	220 J	1300 J	1000 J
	7/14/98	<500	<500	<500	1300	1200
	9/1/98	53	110	220	1500	1200
	12/14/98	61	110	220	1400	1000
	3/9/99	<	93	190	1200	920
MW11	11/11/97	< 0.5	2.8	< 0.5	0.5	4.4
	1/13/98	<5	<5	<5	<5	<5
	7/14/98	<0.5	<0.5	<0.5	<0.5	1
	9/1/98	<1	<1	<1	<1	<1
	12/15/98	<0.5	<0.5	<0.5	<0.5	0.6
	3/6/99	<0.5	<0.5	<0.5	<0.5	0.7
MW21	11/11/97	15	14	4	18	320
	1/14/98	15 J	15 J	<5	20 J	490 J
	7/15/98	12	9	5.8	21	770
	9/2/98	11	7	5	12	500
	12/15/98	14	8	10	20	1100
	3/7/99	12	6	10	22	850
MW31	11/12/97	10	47	0.7	2.7	12
	1/14/98	<5	26	<5	<5	14
	7/15/98	11	13	1	2.8	50
	9/2/98	13	17	<1	4	52
	12/15/98	30	12	<2	3	36
	3/7/99	41	10	<2	2	27
MW41	11/11/97	8	5	< 2.5	12	14
	1/14/98	6	<5	<5	16	11
	7/15/98	3.5	0.8	<0.5	3.5	3.8
	9/2/98	1.7	<0.5	<0.5	3.4	1.5
	12/15/98	2.2	<0.5	<0.5	2.6	1.4
	3/7/99	7	2	1	47	14
MW51	7/14/98	<0.5	<0.5	<0.5	<0.5	1.5
	9/1/98	<0.5	<0.5	<0.5	<0.5	<0.5
	12/15/98	<0.5	<0.5	<0.5	<0.5	<0.5
	3/6/99	<0.5	<0.5	<0.5	<0.5	1
MW61	7/14/98	<0.5	<0.9	<0.5	<0.5	12
	9/1/98	<0.7	<0.6	<0.5	<0.5	5.3
	12/14/98	<0.5	<0.5	<0.5	<0.5	5.8
	3/6/99	0.6	<0.5	<0.5	<0.5	6
MW71	7/15/98	6.4	14	4.2	28	220
	9/1/98	12	15	6	43	500
	12/15/98	14	12	6	31	680
	3/7/99	14	11	6	31	700
MW81	3/24/99	390	30	<0.5	<0.5	0.5

ug/l - Micrograms per liter

J - Estimated

D:\M4133\Reports\Tables\Table19

SUMMARY OF GROUNDWATER VOLATILE ORGANIC COMPOUND CONCENTRATIONS

4120 Buckingham Place

Omaha, Nebraska

Well	Date	Tetrachloroethene ug/l	1,1,1-Trichloroethane ug/l	Trichloroethene ug/l	Vinyl Chloride ug/l
MW4S	11/12/97	1600	1200	20000	< 50
	1/14/98	1400 J	720 J	22000 J	<5
	7/14/98	1500	660	19000	<50
	9/1/98	1900	730	24000	<50
	12/14/98	1500	700	21000	<50
	3/9/99	1800	620	20000	<
MW1I	11/11/97	8.3	<0.5	81	< 0.5
	1/13/98	<5	<5	6	<5
	7/14/98	<0.5	<0.5	7.9	<0.5
	9/1/98	<1	<1	530	<1
	12/15/98	<0.5	<0.5	44	<0.5
	3/6/99	<0.5	<0.5	21	<0.5
MW2I	11/11/97	150	7	540	<1
	1/14/98	230 J	6 J	580 J	<5
	7/15/98	230	8	670	<0.5
	9/2/98	140	5	610	<1
	12/15/98	150	7	670	<2
	3/7/99	120	7	430	<2
MW3I	11/12/97	12	2.1	160	<0.5
	1/14/98	7	<5	250	<5
	7/15/98	10	1.3	1200	<0.5
	9/2/98	10	2	100	<1
	12/15/98	6	<2	790	<2
	3/7/99	8	<2	940	<2
MW4I	11/11/97	67	6	1200	< 2.5
	1/14/98	120	8	1000	<5
	7/15/98	17	1.7	290	<0.5
	9/2/98	19	1.6	80	<0.5
	12/15/98	9.5	1	30	<0.5
	3/7/99	340	27	350	<1
MW5I	7/14/98	0.7	<0.5	15	<0.5
	9/1/98	<0.5	<0.5	5	<0.5
	12/15/98	<0.5	<0.5	1.9	<0.5
	3/6/99	<0.5	<0.5	1.5	0.6
MW6I	7/14/98	5.1	<0.5	76	<0.5
	9/1/98	3.8	<0.5	43	<0.5
	12/14/98	3.8	<0.5	40	<0.5
	3/6/99	4.1	<0.5	48	<0.5
MW7I	7/15/98	180	10	1300	<0.5
	9/1/98	360	15	1900	<2
	12/15/98	300	12	1300	<2
	3/7/99	250	11	1200	<2
MW8I	3/24/99	7.7	<0.5	11	<0.5

ug/l - Micrograms per liter

J - Estimated

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TABLE 21

NATURAL ATTENUATION SCREENING PROTOCOL

4120 Buckingham Place
Omaha, Nebraska

Parameter	Source Area Conditions	Interpretation
Oxygen	<0.5 mg/L	Anaerobic conditions necessary for dechlorination
Methane ¹	>0.5 mg/L	Reductive daughter product
Iron II	>1mg/L	Reductive pathway possible
pH	5<pH<9	Optimal range for reductive pathway
Sulfate	>20 mg/L	May compete with reductive pathway
Nitrate	>1mg/L	May compete with reductive pathway
TOC	<20 mg/L	Potential limiting factor
Oxidation reduction potential	Rel. low to background	Anaerobic conditions in the source area
Chloride	>2x background	Daughter product of organic chlorine
DCE	Rel. Abundant	Daughter product of TCE under reducing conditions
DCA	Rel. Abundant	Daughter product of TCA under reducing conditions
Ethene/ethane	>0.1 mg/L	Daughter product of vinyl chloride
Chloroform	Rel. Abundant	Daughter product of carbon tetrachloride under reducing conditions
Dichloromethane	Rel. Abundant	Daughter product of carbon tetrachloride under reducing conditions

1. Downgradient methane concentration is <0.5 mg/L, supportive of oxidation of vinyl chloride.

mg/L - milligrams per liter

SUMMARY OF GROUNDWATER NATURAL ATTENUATION PARAMETER CONCENTRATIONS

4120 Buckingham Place
Omaha, Nebraska

Monitoring Well	Date	Temperature (degrees C)	pH (units)	Specific Conductance (uS/cm)	Dissolved Oxygen (mg/l)	ORP (mV)	Dissolved Iron (mg/l)	Dissolved Manganese (mg/l)	Chloride (mg/l)	Nitrate as nitrogen (mg/l)	Sulfate (mg/l)	TOC (mg/l)	Methane (ug/l)	Ethane (ug/l)	Ethene (ug/l)
MW1I	11/11/97	11.3	7.04	1780											
	1/13/98	12.9	6.82	1208											
	7/14/98	17.7	6.58	1541	0.47	257	0.25	0.4	128	5.4	256	3.1	1.7		
	9/1/98	16.7	6.54	1698	0.40	86.2	0.2	0.5							
	12/15/98	15.1	6.75	1740	0.33	140.4	0	0.4							
	3/6/99	11	6.68	1754	0.58	151.7	0.2	0.1	163	7.1	323	1.8	0.77	<0.5	<0.5
MW2I	11/11/97	12.5	6.48	1832											
	1/13/98	14.05	6.85	1880											
	7/15/98	18.5	6.81	1490	1.68	122	0.7	<0.1	9.4	21.6	270	0.7	<0.5		
	9/2/98	18.9	6.70	1386	1.98	25	4.3	0.4							
	12/15/98	15.1	7.05	1510	2.00	57.2	0.5	0.1							
	3/7/99	13	6.88	1520	2.22	68.1	1.1	0.1	101	21	256	0.6	0.64	<0.5	<0.5
MW3I	11/12/97	12.9	7.20	1600											
	1/14/98	13.4	6.99	1610											
	7/15/98	19.1	7.00	1520	0.21	158	0.2	1.7	151	7.5	208	3.2	43		
	9/2/98	18.1	6.97	1594	0.40	18.5	0.5	1.7							
	12/15/98	15.9	7.30	1710	0.90	105.9	0.1	1.8							
	3/7/99	14.8	7.00	1752	0.27	100.8	0.3	0.8	168	10.6	196	1.9	16	12	7.2
MW4I	11/11/97	12.1	6.22	2020											
	1/14/98	13.2	6.84	2750											
	7/15/98	20	6.61	2250	0.42	288	0.7	<0.1	215	14.8	435	2.4	<0.5		
	9/2/98	18.4	6.54	2220	0.56	41.8	1	<0.1							
	12/15/98	15.2	6.87	2260	0.52	100.4	5	0.1							
	3/7/99	14.2	6.81	2210	0.51	105.4	1.8	0.1	196	13.5	389	1.7			
MW5I	7/14/98	18.7	6.46	1666	0.42	157	0.6	2.1	227	2.5	226	1.4	1.6		
	9/1/98	17.7	6.44	1798	0.31	44.2	1.5	1.3							
	12/15/98	15	6.59	1690	0.22	133	0.6	0.65							
	3/6/99	11.9	6.51	1727	0.31	152.8	0.2	0.1	200	4.2	336	1.4	13	<0.5	<0.5
MW6I	7/14/98	18.3	6.50	1888	0.34	116	0.9	2.4	216	9.2	276	1.8	2.8		
	9/1/98	15.5	6.51	1820	0.99	103	0.5	0.85							
	12/15/98	15.7	6.66	1830	0.63	49.1	3.25	0.5							
	3/6/99	10	6.71	1770	1.16	114.6	0.5	0.1	185	14.1	291	1.0	<0.5	<0.5	<0.5
MW7I	7/15/98	19.7	7.30	1590	0.52	-320	0.5	1.3	116	15.5	299	4.3	7.9		
	9/2/98	15.7	7.20	1400	2.22	135.4	0.1	1.2							
	12/15/98	14.8	7.52	1680	1.81	115.2	0	0.6							

SUMMARY OF GROUNDWATER NATURAL ATTENUATION PARAMETER CONCENTRATIONS

4120 Buckingham Place
Omaha, Nebraska

Monitoring Well	Date	Temperature (degrees C)	pH (units)	Specific Conductance (uS/cm)	Dissolved Oxygen (mg/l)	ORP (mV)	Dissolved Iron (mg/l)	Dissolved Manganese (mg/l)	Chloride (mg/l)	Nitrate as nitrogen (mg/l)	Sulfate (mg/l)	TOC (mg/l)	Methane (ug/l)	Ethane (ug/l)	Ethene (ug/l)
	3/7/99	14.5	7.30	1690	1.76	115	0.2	0.1	114	18.9	298	0.9	0.53	<0.5	<0.5
MW8I	3/11/99	14.9	6.61	1114	1.51	-201.6	0.5	1.3	47.1	12.4	201	2.9	<0.5	<0.5	<0.5
	3/24/99	15.5	6.47	1159	0.27	24.5	0.5	<0.2					<0.5	<0.5	<0.5
MW4S	11/12/97	9.16	7.17	3500											
	1/14/98	10.6	6.77	3520											
	7/14/98	17.5	6.79	2600	0.94	42	5	1.4	349	14.7	466	5.3	1.5		
	9/1/98	18.1	6.28	2800	1.50	134	2.1	1.7							
	12/15/98	14	6.51	2630	1.13	250	0.7	1.45							
	3/9/99	12.1	6.93	3150	0.45	187.4	2.5	2.4	377	13.9	603	5.1	1.2	<0.5	<0.5

C - Celsius

uS/cm - microsiemens per centimeter

mg/l - milligrams per liter

mV - millivolts

Blank indicates no sample analyzed

TOC - Total organic carbon

TABLE 23

SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN SOIL



4120 Buckingham Place
Omaha, Nebraska

Chemical	Maximum Detected Concentration (ug/kg)	Risk Based Concentration (RBC) (ug/kg)	Soil Screening Level - Soil to Air (SSL) (ug/kg)	Maximum detect greater than RBC or SSL?	Selected as Chemical of Potential Concern?
1,1,1-Trichloroethane	69000	1600000	1200000	NO	NO
1,1-Dichloroethane	790	7800000	1300000	NO	NO
1,1-Dichloroethene	780	1100	70	YES	YES
1,2-Dichlorobenzene	4500	7000000	560000	NO	NO
2-Butanone	130000	47000000	20000000 ¹	NO	NO
2-Methylnaphthalene	17000	1600000	NA ²	NO	NO
2-Methylphenol	170	3900000	N/A ³	NO	NO
4,4'-DDD	5100	2700	N/A	YES	YES
4,4'-DDT	300	1900	NV ⁴	NO	NO
4-Methyl-2-pentanone	5400	6300000	2100000 ¹	NO	NO
4-Methylphenol	130	390000	NA	NO	NO
Aroclor 1248	810000	7800000	100000000	NO	NO
Aldrin	240000	38	3000	YES	YES
alpha-Chlordane	40000	1800 ⁵	20000 ⁵	YES	YES
Benzene	220	22000	800	NO	NO
Benzo(a)anthracene	72	870	N/A	NO	NO
Benzo(a)pyrene	70	87	N/A	NO	NO
Benzo(b)fluoranthene	35	870	N/A	NO	NO
Benzyl alcohol	110	23000000	NA	NO	NO
bis(2-Ethylhexyl)phthalate	90	46000	31000000	NO	NO
Butyl benzyl phthalate	110	16000000	930000	NO	NO
Carbon disulfide	60	7800000	720000	NO	NO
Carbon tetrachloride	250	4900	300	NO	NO
Chlorobenzene	1	1600000	130000	NO	NO
Chloroform	6500	100000	300	YES	YES
delta-BHC	26	NA	NA	NO	NO ⁶
Di-n-butyl phthalate	1200	7800000	2300000	NO	NO
Dieldrin	48000	40	1000	YES	YES
Diethyl phthalate	28	63000000	2000000	NO	NO
Endrin	1500	23000	N/A	NO	NO
Endrin ketone	47	NA	NA	NO	NO ⁷

TABLE 23

SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN SOIL



4120 Buckingham Place
Omaha, Nebraska

Chemical	Maximum Detected Concentration (ug/kg)	Risk Based Concentration (RBC) (ug/kg)	Soil Screening Level - Soil to Air (SSL) (ug/kg)	Maximum detect greater than RBC or SSL?	Selected as Chemical of Potential Concern?
Ethylbenzene	5300	7800000	400000	NO	NO
Fluoranthene	210	3100000	N/A	NO	NO
gamma-Chlordane	97000	1800 ⁵	20000 ⁵	YES	YES
Heptachlor	12000	140	100	YES	YES
Heptachlor epoxide	450	70	5000	YES	YES
Methylene chloride	3200	85000	13000	NO	NO
Naphthalene	67	1600000	N/A	NO	NO
Pentachlorophenol	160000	5300	N/A	YES	NO ⁸
Phenanthrene	2600	NA	NA	NO	NO ⁹
Pyrene	2700	2300000	N/A	NO	NO
Styrene	3	16000000	1500000	NO	NO
Trichloroethene	67000	12000	11000	YES	YES
Toluene	93000	16000000	650000	NO	NO
Trichloroethene	250000	58000	5000	YES	YES

Notes:

- 1) Calculated based on methodology provided in Attachment 1.
- 2) NA = No value provided for this chemical; value cannot be calculated due to lack of toxicity information.
- 3) N/A = No toxicity data is available for the inhalation route; therefore, no SSL is calculated for this chemical (U.S. EPA, 1996).
- 4) NV = Chemical is not considered volatile; therefore, no SSL is calculated for this chemical (U.S. EPA, 1996).
- 5) Value for chlordane, which represents a mixture including this isomer, was used as a surrogate.
- 6) There is no RBC or SSL to which the data for delta-BHC can be compared due to a lack of toxicity information. However, this chemical was detected in only 1 out of 71 samples at a very low concentration. Therefore, delta-BHC was not identified as a COPC.
- 7) There is no RBC or SSL to which the data for endrin ketone can be compared due to a lack of toxicity information. However, this chemical was detected in only 5 out of 66 samples at very low concentrations. Therefore, endrin ketone was not identified as a COPC.
- 8) Chemical was detected in only 1 out of 38 samples.
- 9) There is no RBC or SSL to which the data for phenanthrene can be compared due to a lack of toxicity information. However, this chemical was detected in only 5 out of 38 samples at relatively low concentrations (while the maximum was 2600 ug/kg, the next highest value was 310 ug/kg, and the remaining values were less than 100 ug/kg). Therefore, phenanthrene was not identified as a COPC.

TABLE 24
CONSTITUENTS OF CONCERN

4120 Buckingham Place
Omaha, Nebraska

Soil
4,4'-DDD
Aldrin
alpha-Chlordane
gamma-Chlordane
Dieldrin
Heptachlor
Heptachlor Epoxide
1,1-Dichloroethene
Chloroform
Tetrachloroethene
Trichloroethene

Groundwater
Carbon Tetrachloride
1,1-Dichloroethene
cis-1,2-Dichloroethene
Tetrachloroethene
1,1,1-Trichloroethane
Trichloroethene

COC CONCENTRATIONS IN SOIL

Buckingham Place Facility
Omaha, Nebraska

Analyte	MW1-2	MW1-71	MW1-9	MW1-90	MW2-10	MW2-2
1,1-Dichloroethene	5 U	5 U	5 U	5 U	5 U	5 UJ
4,4-DDD	330 U		3.3 U		3.3 U	3.3 U
Aldrin	1400		1.7 U		1.7 U	1.7 U
alpha-Chlordane	1000		1.7 U		1.7 U	1.7 U
Chloroform	6	5 U	5 U	5 U	5 U	5 UJ
Dieldrin	4600		3.3 U		3.3 U	3.3 U
gamma-Chlordane	4400		1.7 U		1.7 U	1.7 U
Heptachlor	2100		1.7 U		1.7 U	1.7 U
Hepthachor Epoxide	450		1.7 U		1.7 U	1.7 U
Pentachlorophenol	1600 U		1600 U		2000 U	2000 U
Tetrachloroethene	490	5 U	5 U	5 U	8	140 J
Trichloroethene	85000	130	120	240	5 U	7 J

COC CONCENTRATIONS IN SOIL

Buckingham Place Facility
Omaha, Nebraska

Analyte	MW3-10	MW3-2.5	MW4D-10	MW4D-5.5	MW6I3	MW6I5
1,1-Dichloroethene	5 U	5 UJ	5 U	6		
4,4-DDD	3.4	3.3 U	3.3 U	5.4		
Aldrin	1.7 U	1.7 U	1.7 U	1.7 U		
alpha-Chlordane	1.7 U	1.7 U	1.7 U	1.7 U		
Chloroform	5 U	5 UJ	6	56		
Dieldrin	3.3 U	3.3 U	3.3 U	3.3 U		
gamma-Chlordane	1.7 U	1.7 U	1.7 U	1.7 U		
Heptachlor	1.7 U	1.7 U	1.7 U	1.7 U		
Hepthachor Epoxide	1.7 U	1.7 U	1.7 U	1.7 U		
Pentachlorophenol	1600 U	1600 U	2000 U	1600 U	200 U	200 U
Tetrachloroethene	5 U	9 J	18	560		
Trichloroethene	5	15 J	16	360		

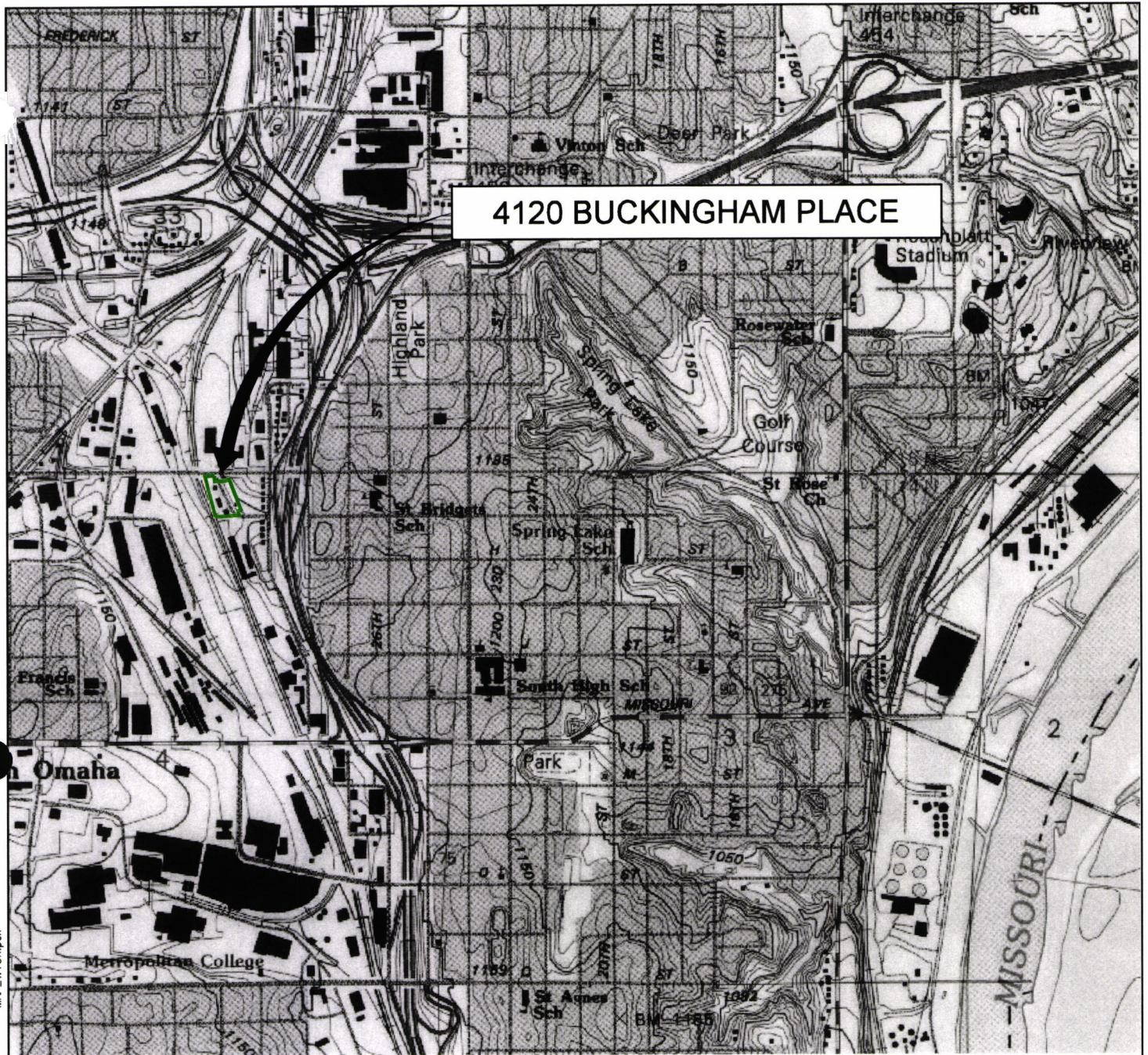
TABLE 26
POTENTIAL CORRECTIVE MEASURES TECHNOLOGIES

4120 Buckingham Place
Omaha, Nebraska

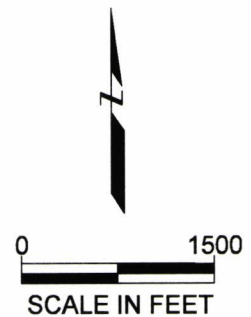
Media	Technology Classification	Technology
Soil	In Situ Treatment Technologies	Monitored Natural Attenuation
		Chemical Oxidation
		Vapor Extraction
		Phytoremediation
	Ex Situ Treatment Technology ¹	Enhanced Bioremediation
		Reductive Dechlorination
		Vapor Extraction
		Thermal Desorption
		Incineration
		Disposal
	Barrier Technologies	Surface Cover
		Asphalt/Concrete Cap
		RCRA Cap
	Institutional Controls	
Groundwater	In Situ Treatment Technologies	Enhanced Bioremediation
		Air Sparging/Vapor Extraction
		Reductive Dechlorination
		Chemical Oxidation
		Monitored Natural Attenuation
	Ex Situ Treatment Technologies ²	Bioreactor
		Carbon Adsorption
		Air Stripping
		UV Oxidation
	Containment Technologies	Hydraulic Barrier ²
		Physical Barrier
		Chemical Barrier
	Institutional Controls	

¹ Assumes soil excavation

² Assumes groundwater pumping or dual phase extraction



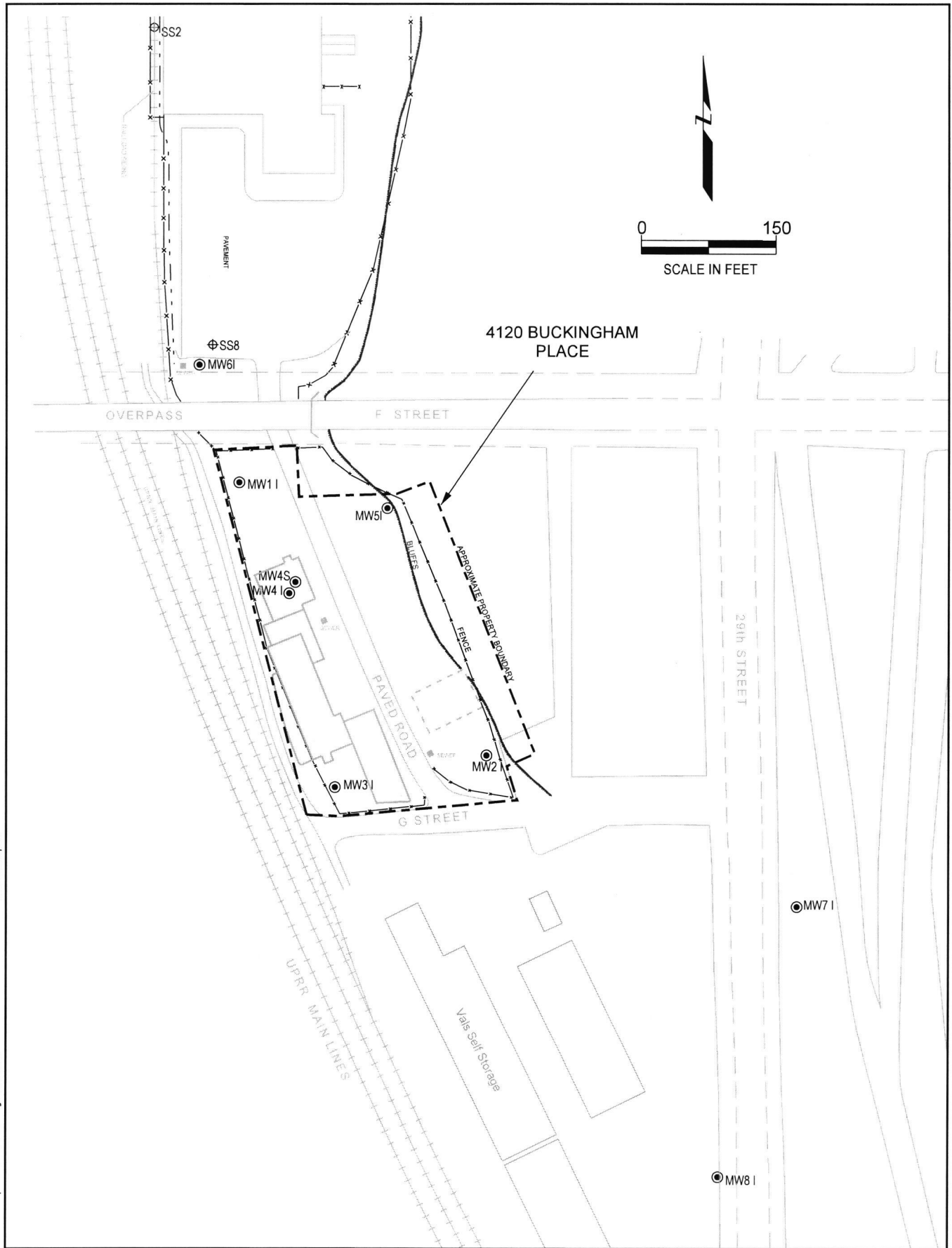
MAP SOURCE:
USGS 7.5 Minute Quadrangle Map, Omaha South, Nebraska-Iowa,
Scale : 1: 24,000,



SITE LOCATION MAP
4120 Buckingham Place
Omaha, Nebraska

Project No.
4133.000

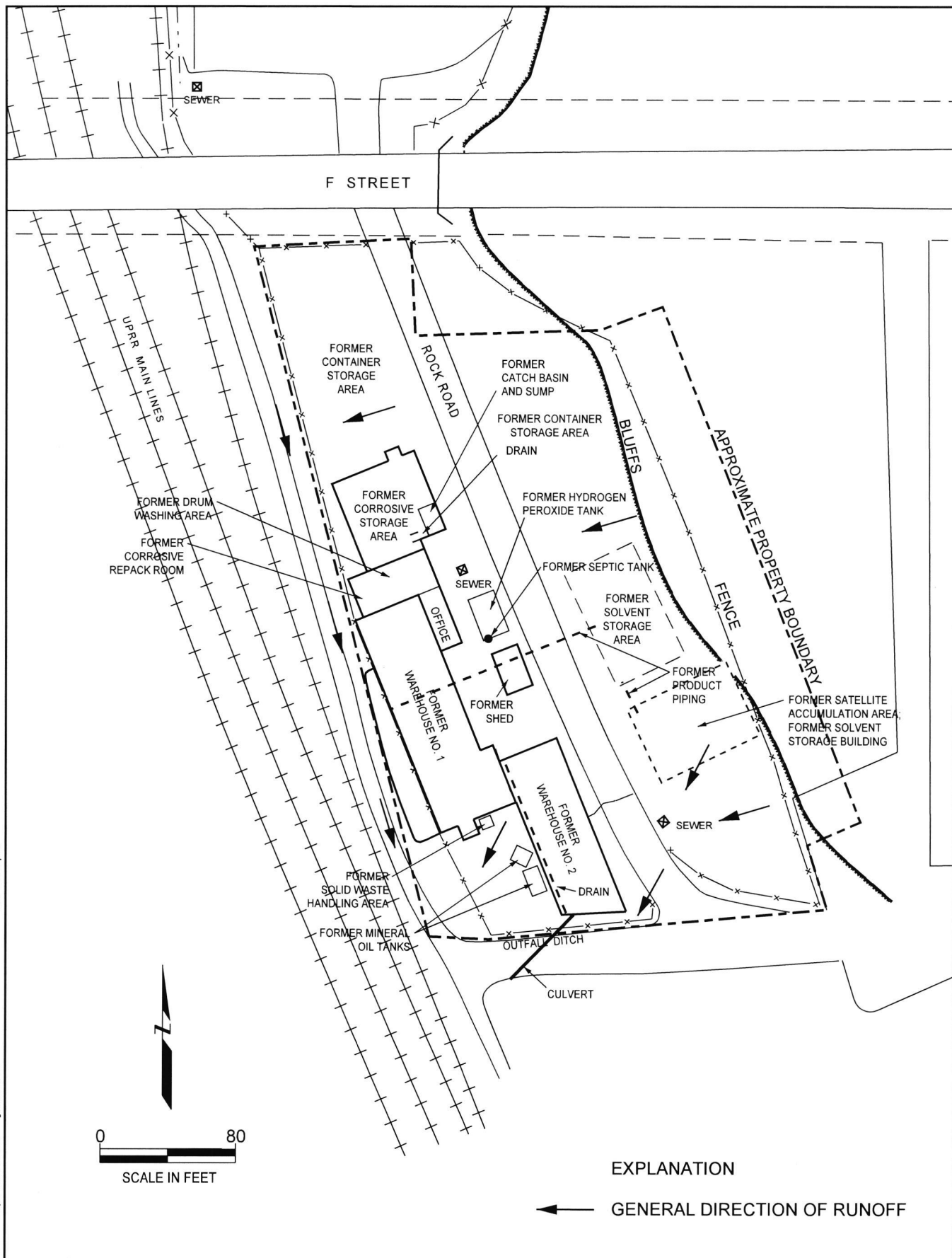
Figure
1



SITE MAP
 4120 Buckingham Place
 Omaha, Nebraska

Project No.
 4133.000

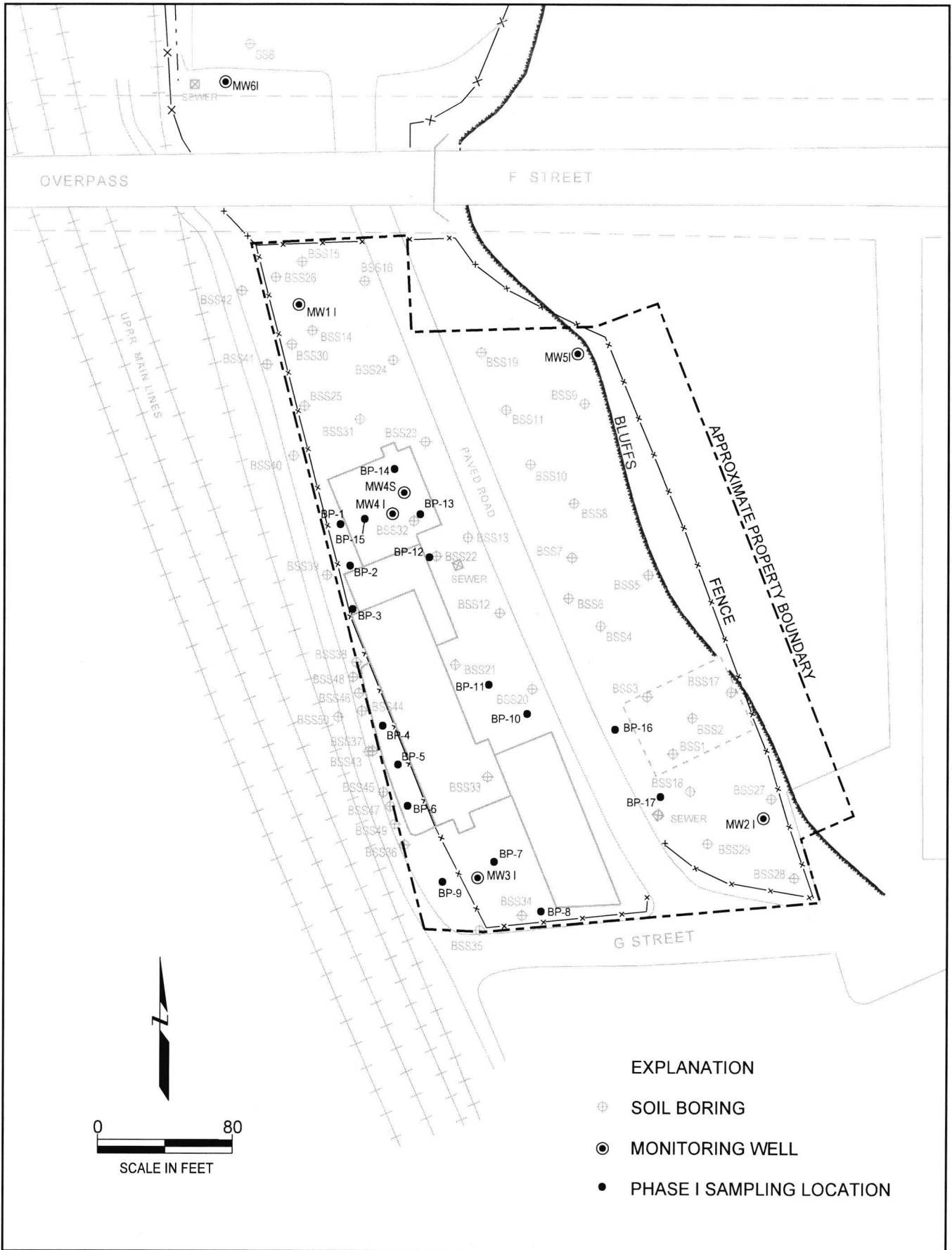
Figure
2



FORMER SITE CONDITIONS
(TO 1989)
4120 Buckingham Place
Omaha, Nebraska

Project No.
4133.000

Figure
3



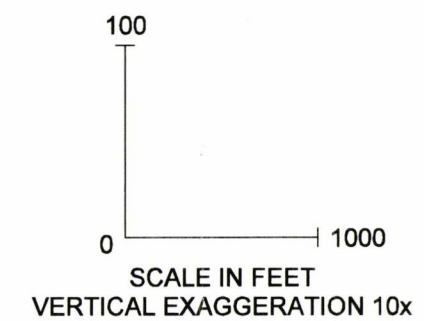
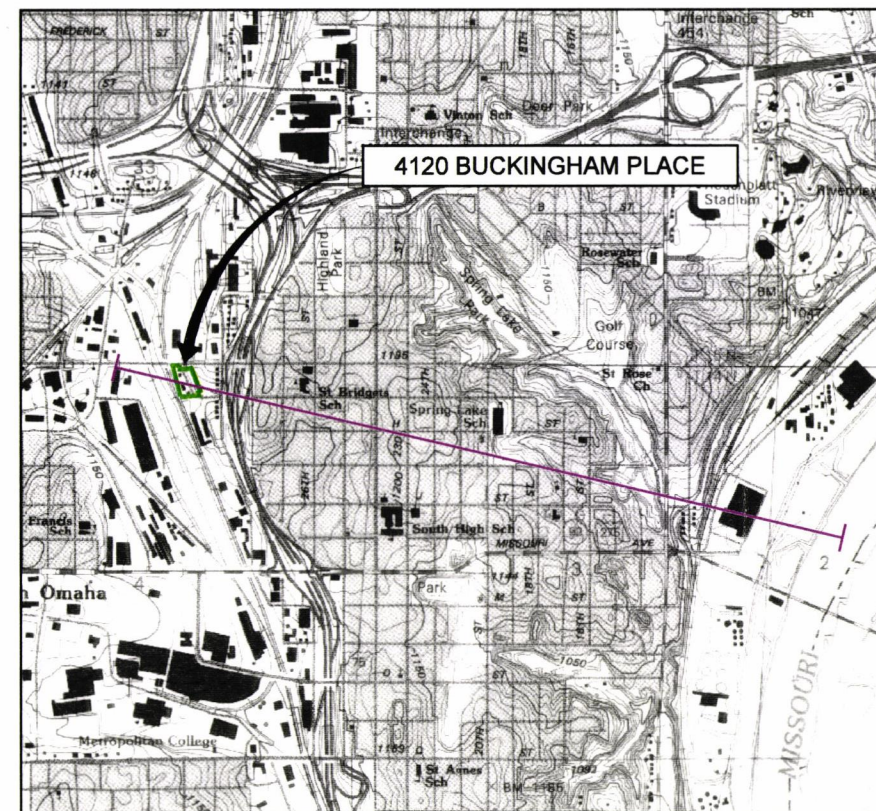
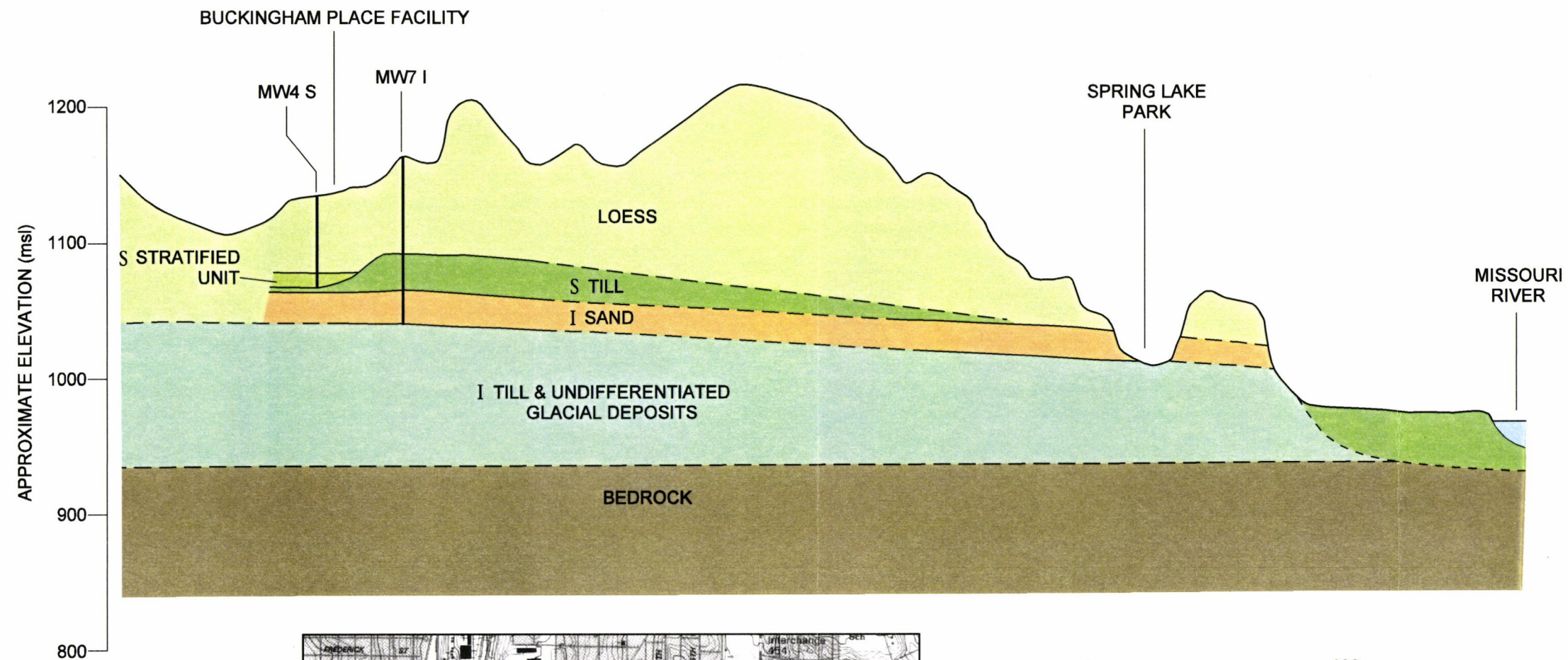
SOIL SAMPLE LOCATIONS
4120 Buckingham Place
Omaha, Nebraska

Project No.
4133.000

Figure
4

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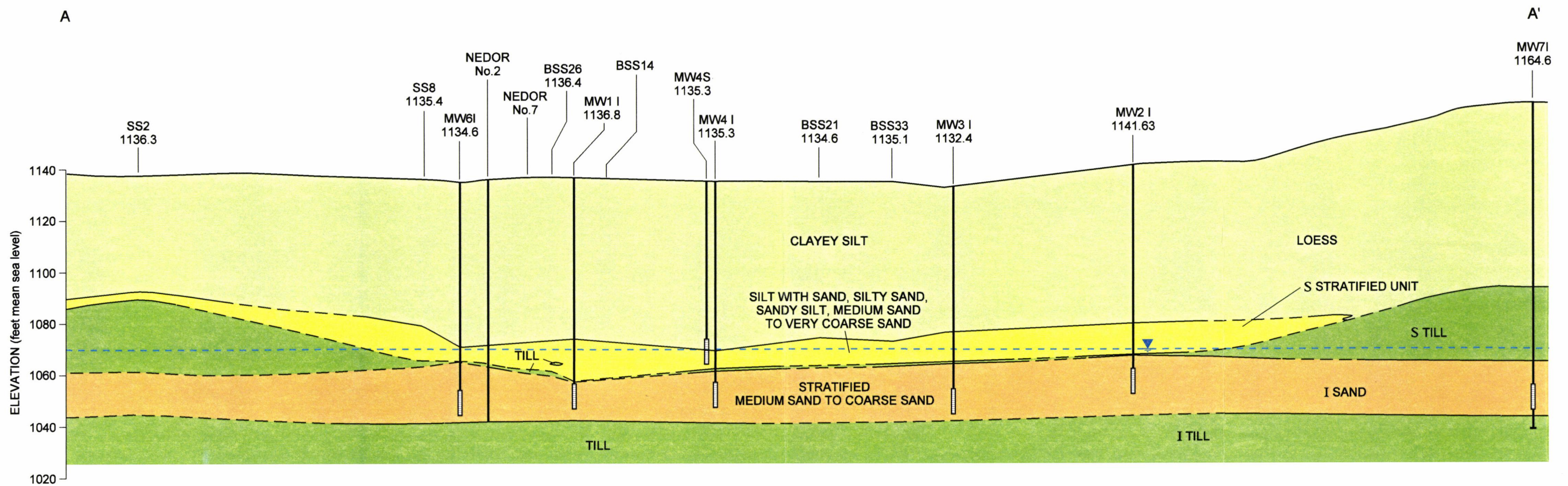


CONCEPTUAL REGIONAL
HYDROSTRATIGRAPHIC CROSS SECTION
4120 Buckingham Place
Omaha, Nebraska



Project No.
4133.000

Figure
5



EXPLANATION

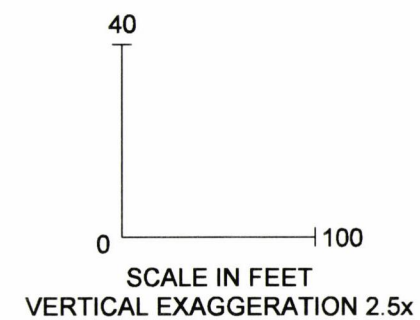
WELL SCREEN

APPROXIMATE WATER LEVEL (MEASURED IN I-SERIES WELLS)

NEDOR NEBRASKA DEPARTMENT OF ROADS

NOTE:

The alignment of this cross section is shown on Figure 7.

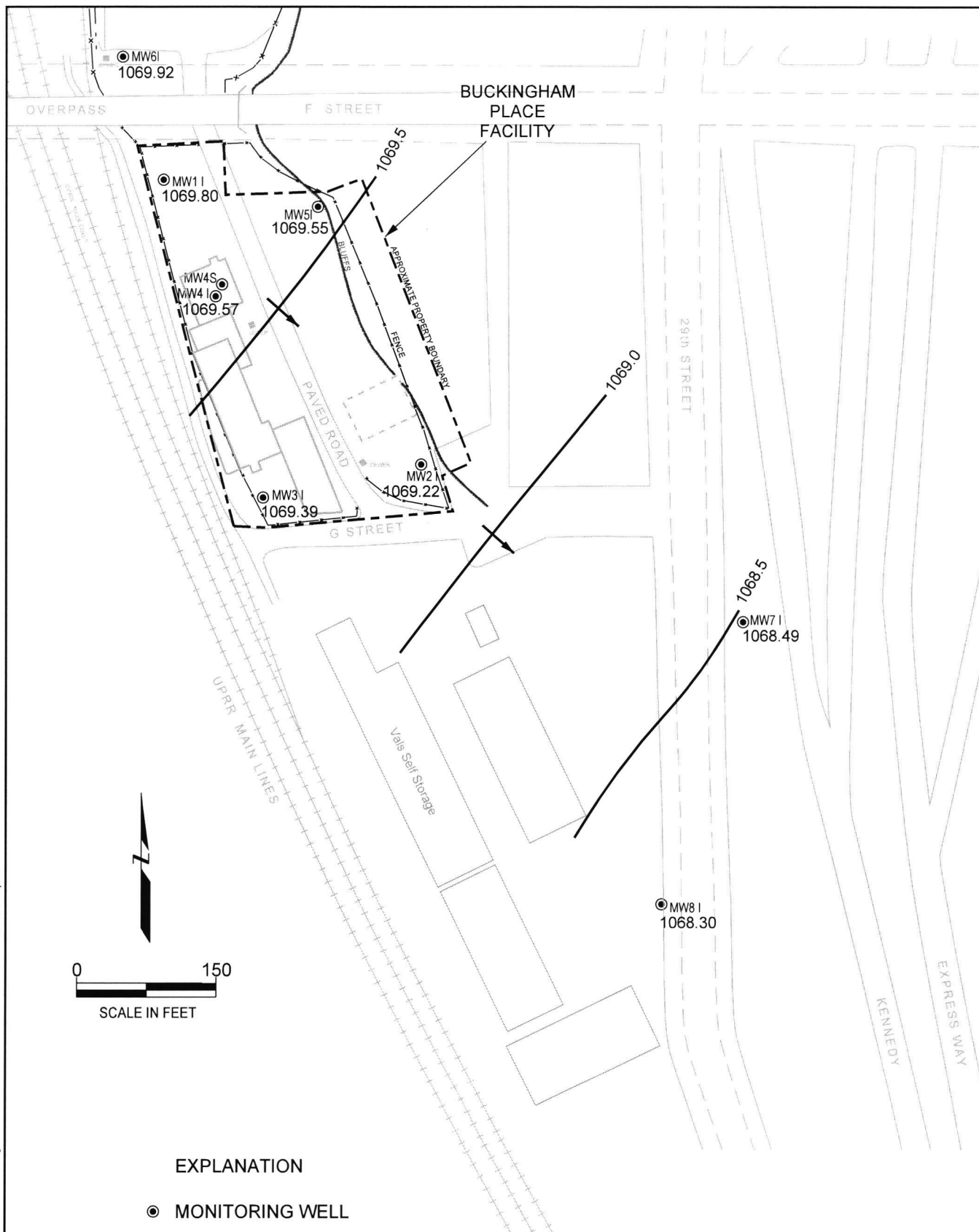


HYDROSTRATIGRAPHIC CROSS SECTION
4120 Buckingham Place
Omaha, Nebraska



Project No.
4133.000

Figure
6



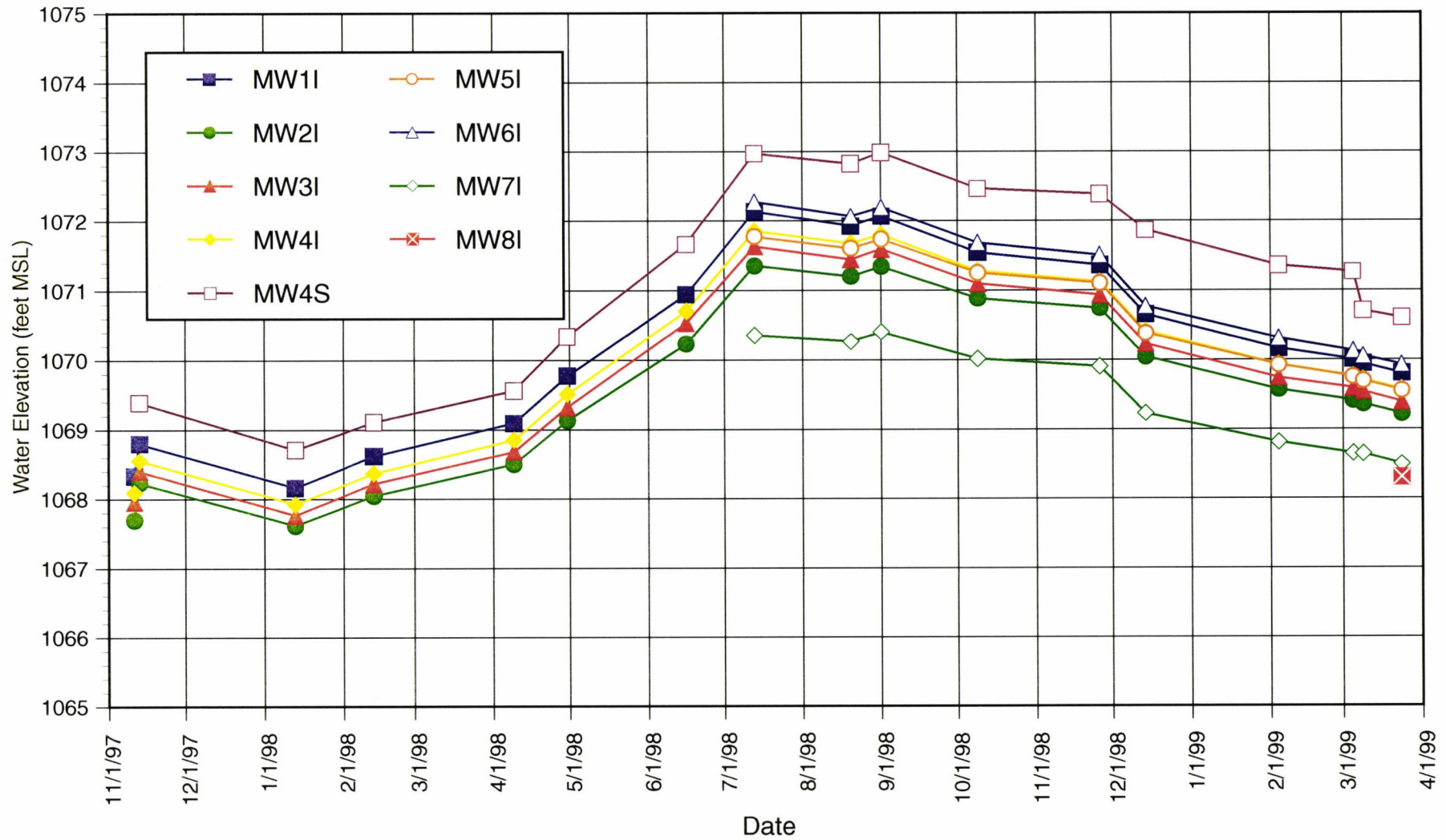
GROUNDWATER FLOW MAP
4120 Buckingham Place
Omaha, Nebraska

Project No.
4133.000

Figure
9

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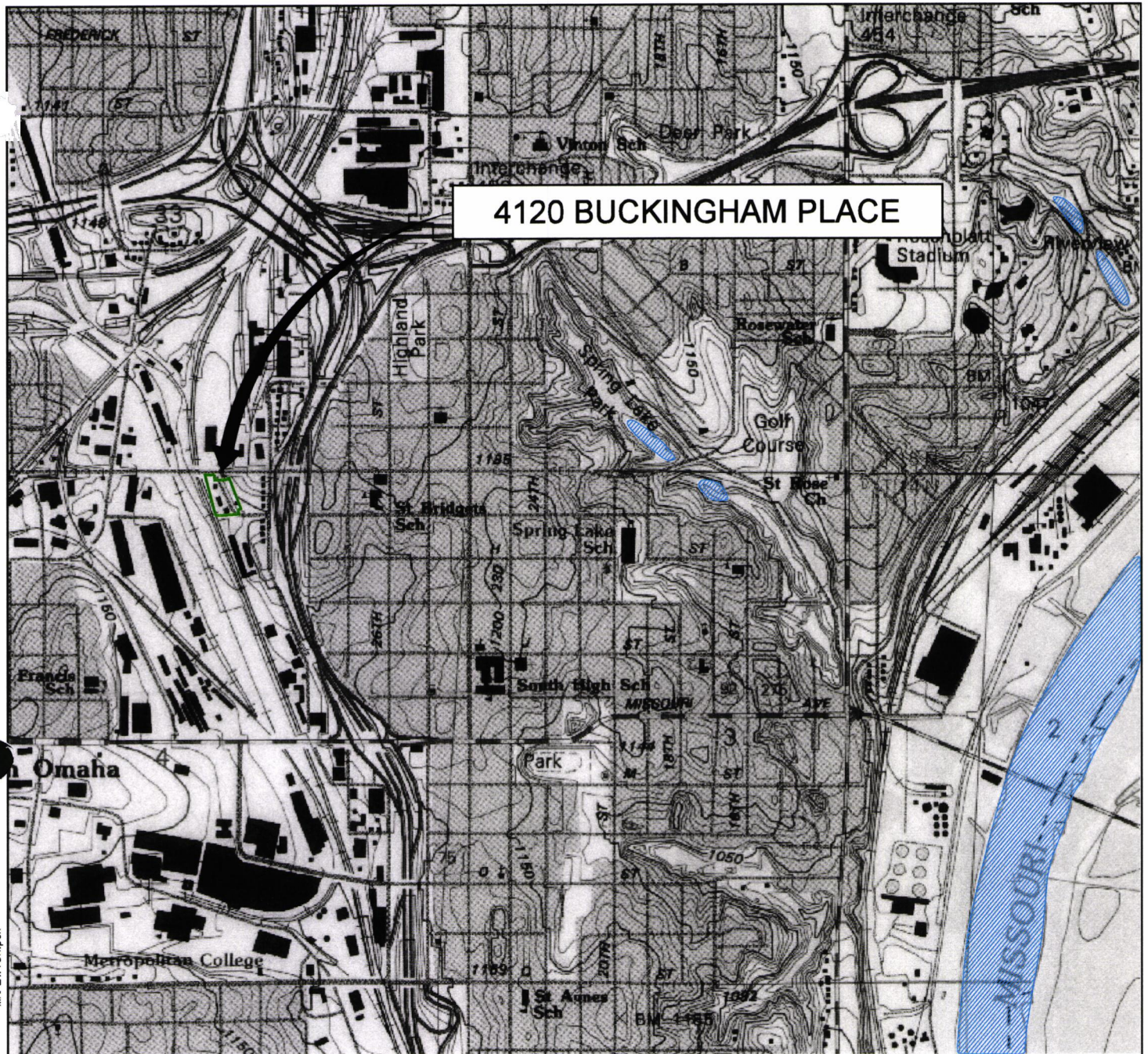
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HYDROGRAPH
4120 Buckingham Place
Omaha, Nebraska

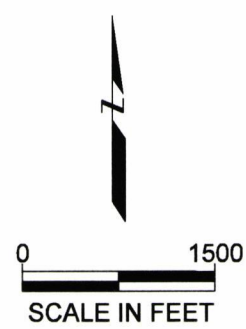
Project No.
4133.000

Figure
10



4120 BUCKINGHAM PLACE

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USGS 7.5 Minute Quadrangle Map, Omaha South, Nebraska-Iowa,
Scale : 1: 24,000,

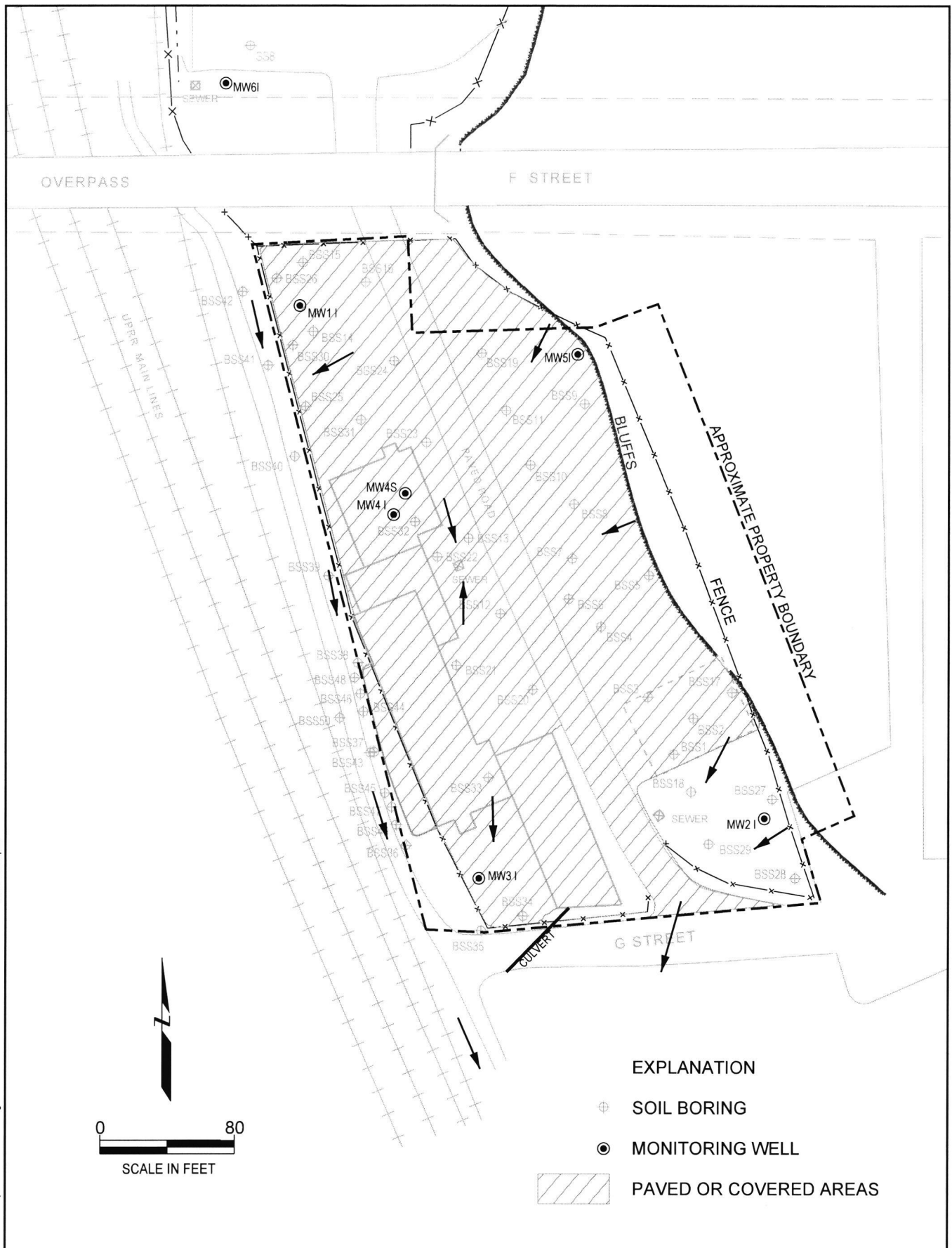


SURFACE WATER LOCATIONS
4120 Buckingham Place
Omaha, Nebraska

Project No.
4133.000
Figure
11

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MAP_4mv.pen

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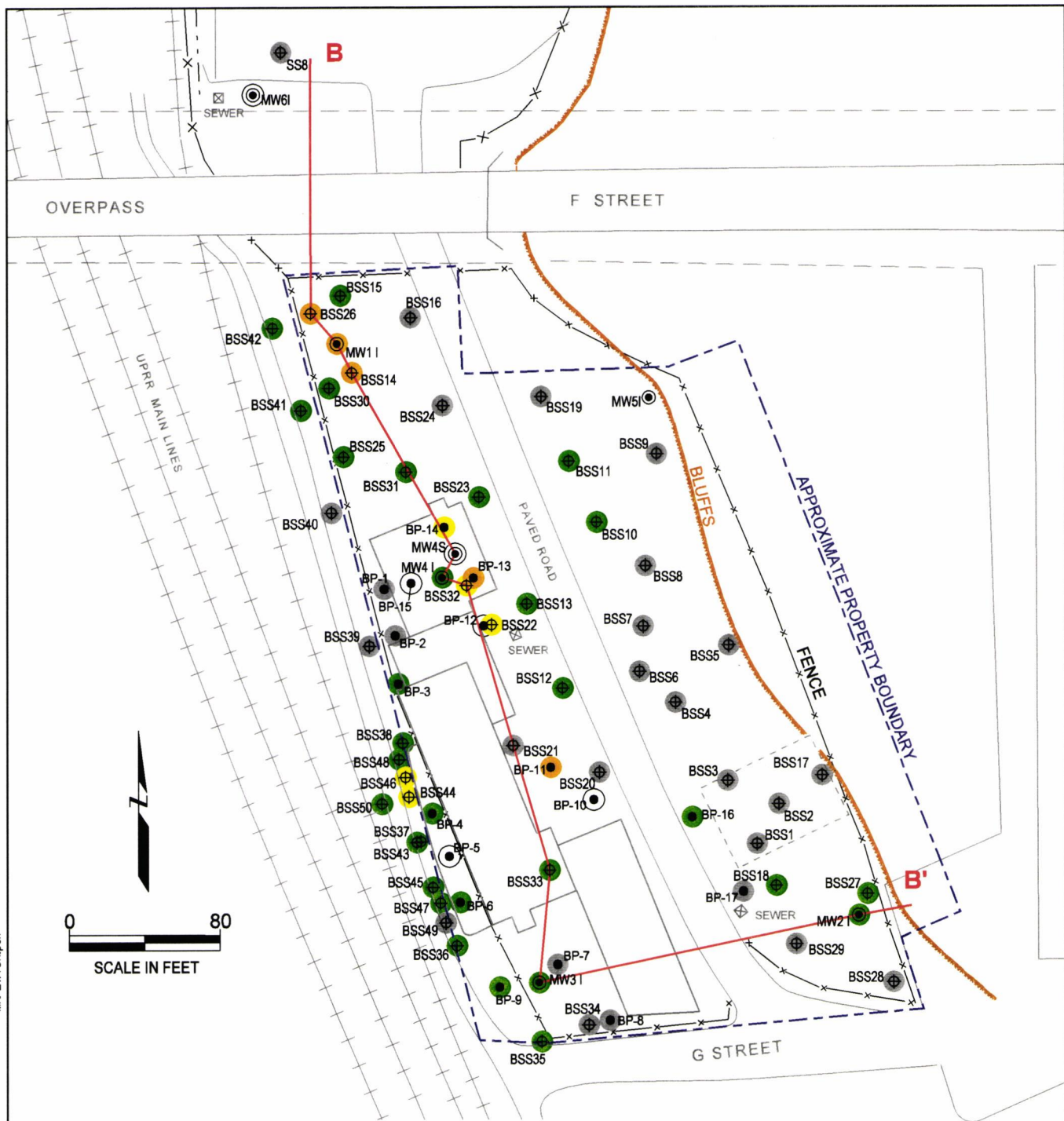
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SURFACE WATER DRAINAGE
 4120 Buckingham Place
 Omaha, Nebraska

Project No.
 4133.000

Figure
12



MAP_WT3X.pen

EXPLANATION

- ⊕ SOIL BORING
- MONITORING WELL
- PHASE I SAMPLING LOCATION

B—B' CROSS SECTION LOCATION

- TCE CONCENTRATION >10,000 µg/kg
- TCE CONCENTRATION 5000-10,000 µg/kg
- TCE CONCENTRATION <5000 µg/kg
- TCE NOT DETECTED AT OR ABOVE REPORTING LIMITS
- NO SOIL SAMPLES ANALYZED FOR TCE



MAXIMUM TCE CONCENTRATIONS DETECTED AT
SOIL SAMPLING LOCATIONS
4120 Buckingham Place
Omaha, Nebraska

Project No.
4133.000

Figure
13

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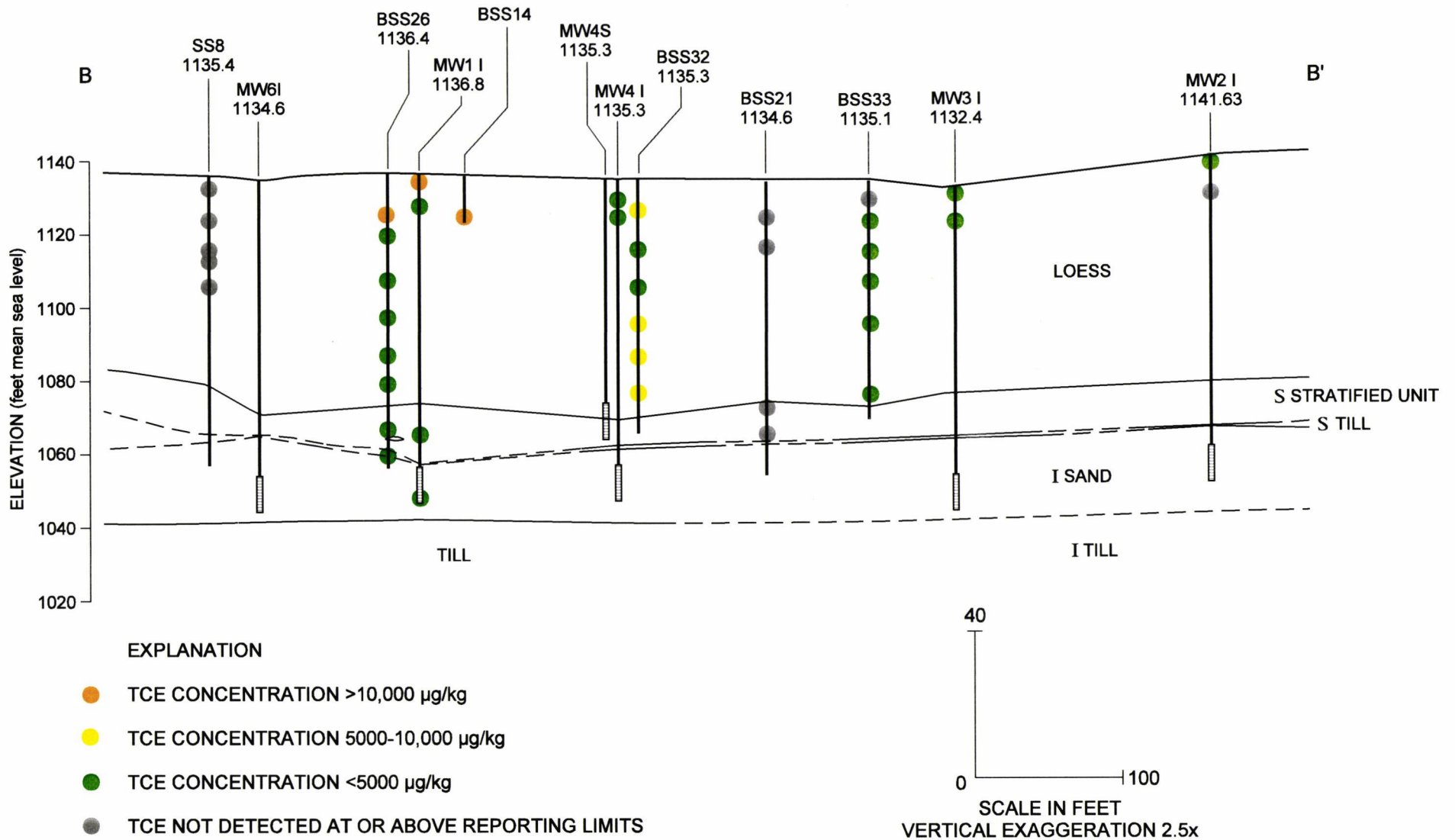
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MAP_WT3X.pen



TCE CONCENTRATION PROFILE
4120 Buckingham Place
Omaha, Nebraska

Project No.
4133.000

Figure
14

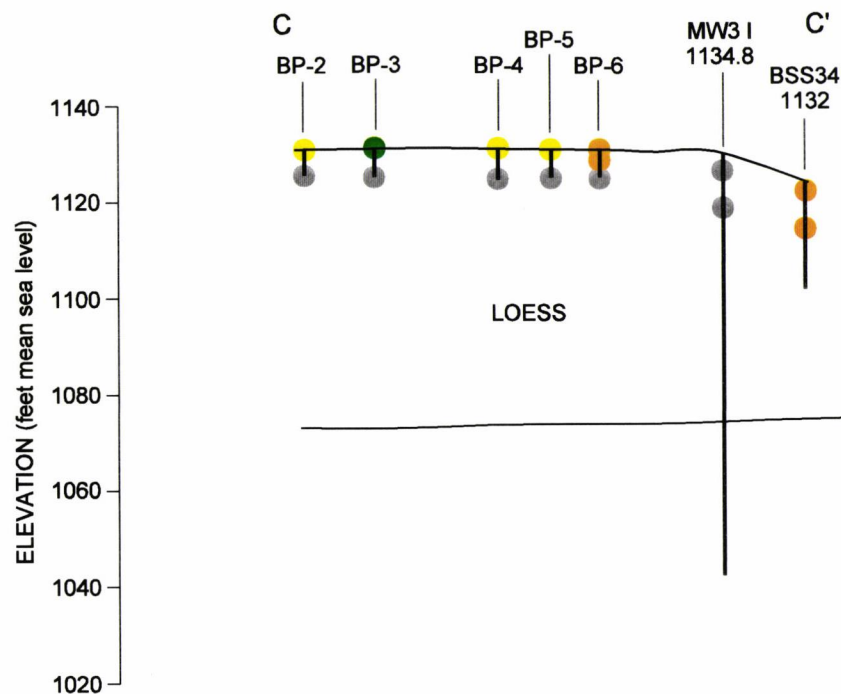
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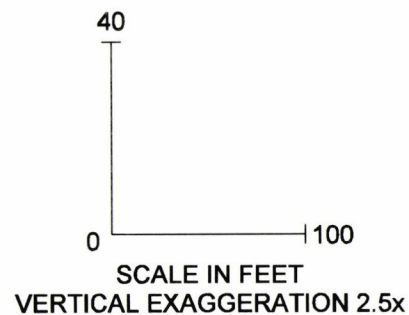
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EXPLANATION

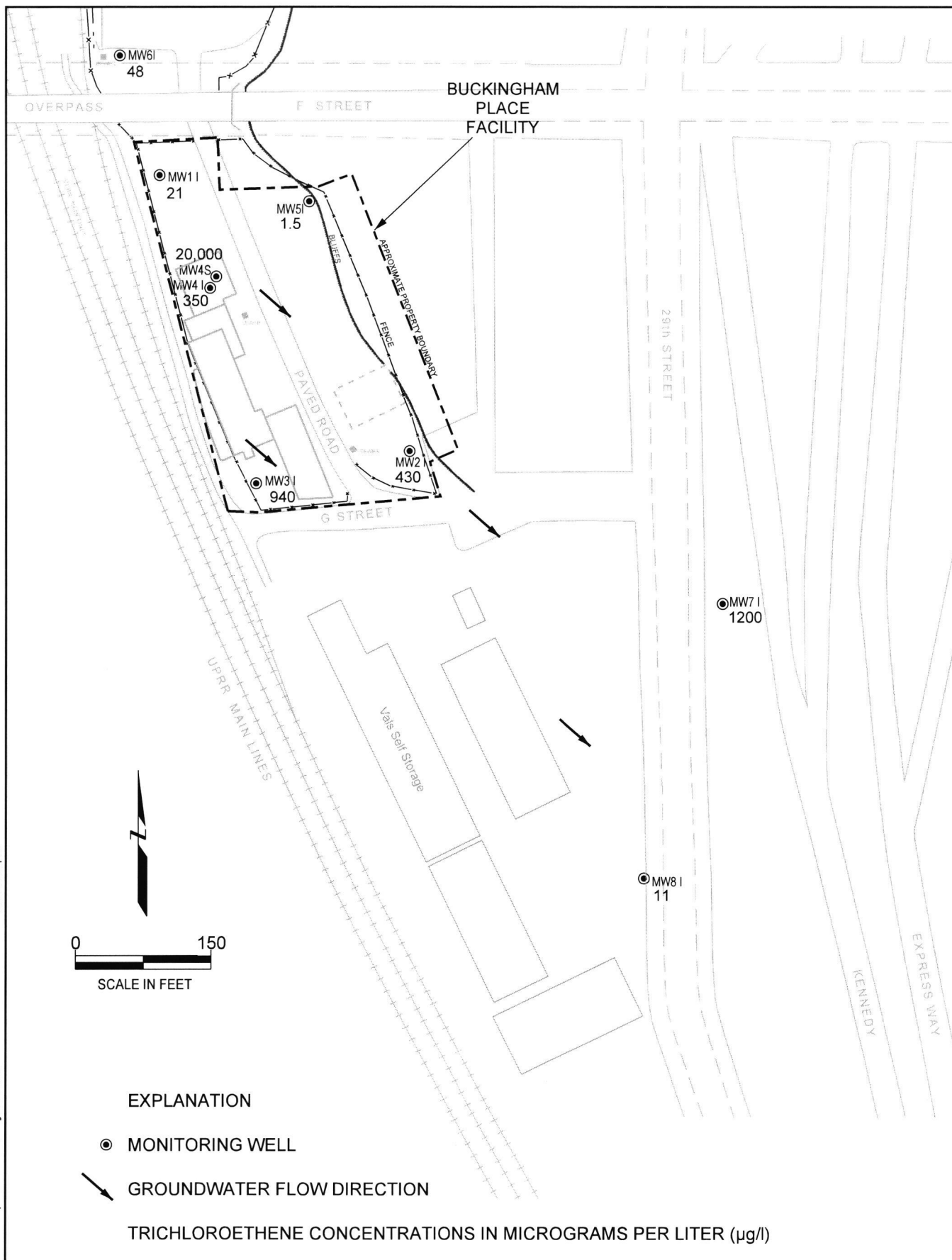
- DIELDRIN CONCENTRATION >1000 µg/kg
- DIELDRIN CONCENTRATION 40-1000 µg/kg
- DIELDRIN CONCENTRATION <40 µg/kg
- DIELDRIN NOT DETECTED AT OR ABOVE REPORTING LIMITS



DIELDRIN CONCENTRATION PROFILE
4120 Buckingham Place
Omaha, Nebraska

Project No.
4133.000

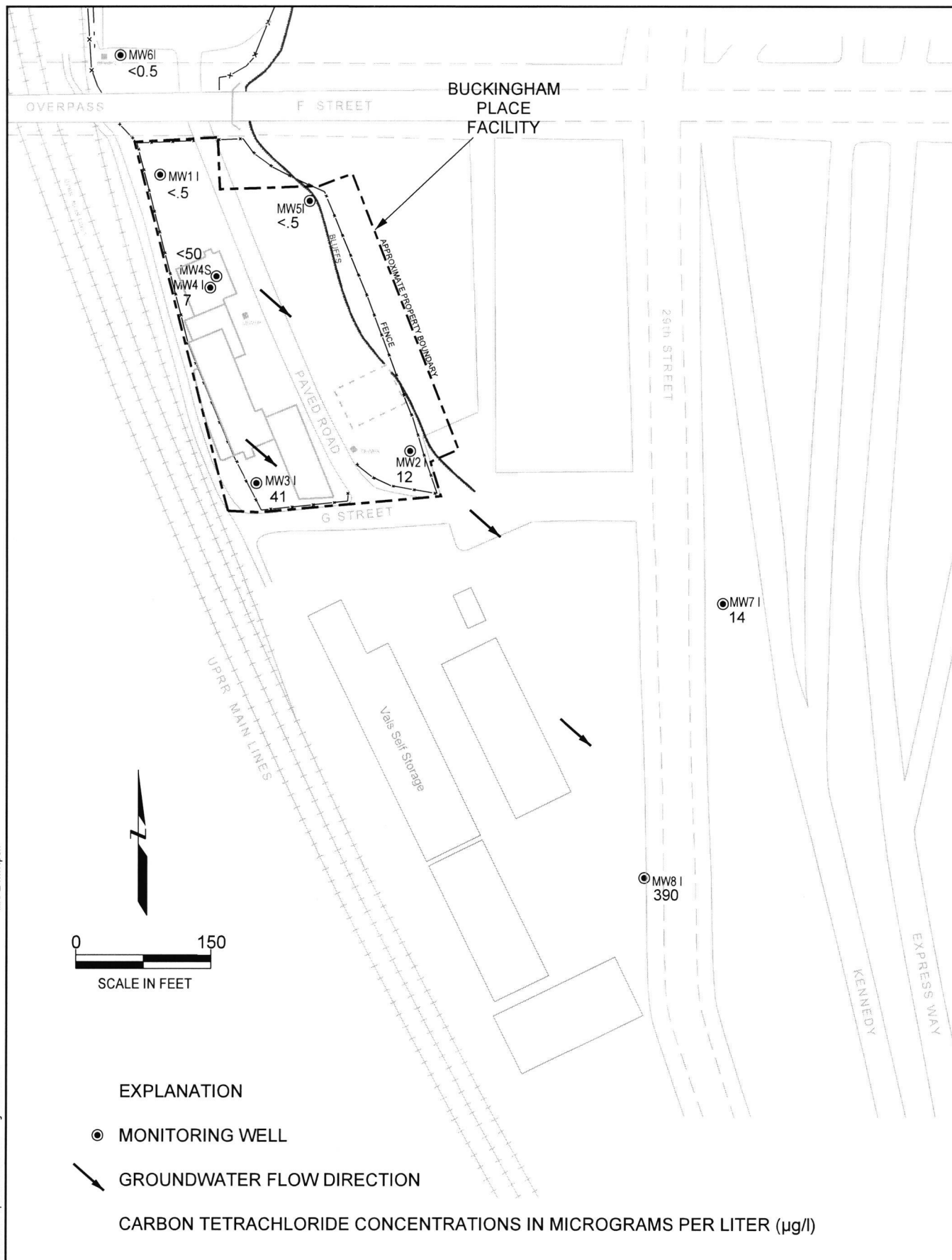
Figure
16



TRICHLOROETHENE CONCENTRATIONS IN GROUNDWATER
MARCH 1999
4120 Buckingham Place
Omaha, Nebraska

Project No.
4133.000

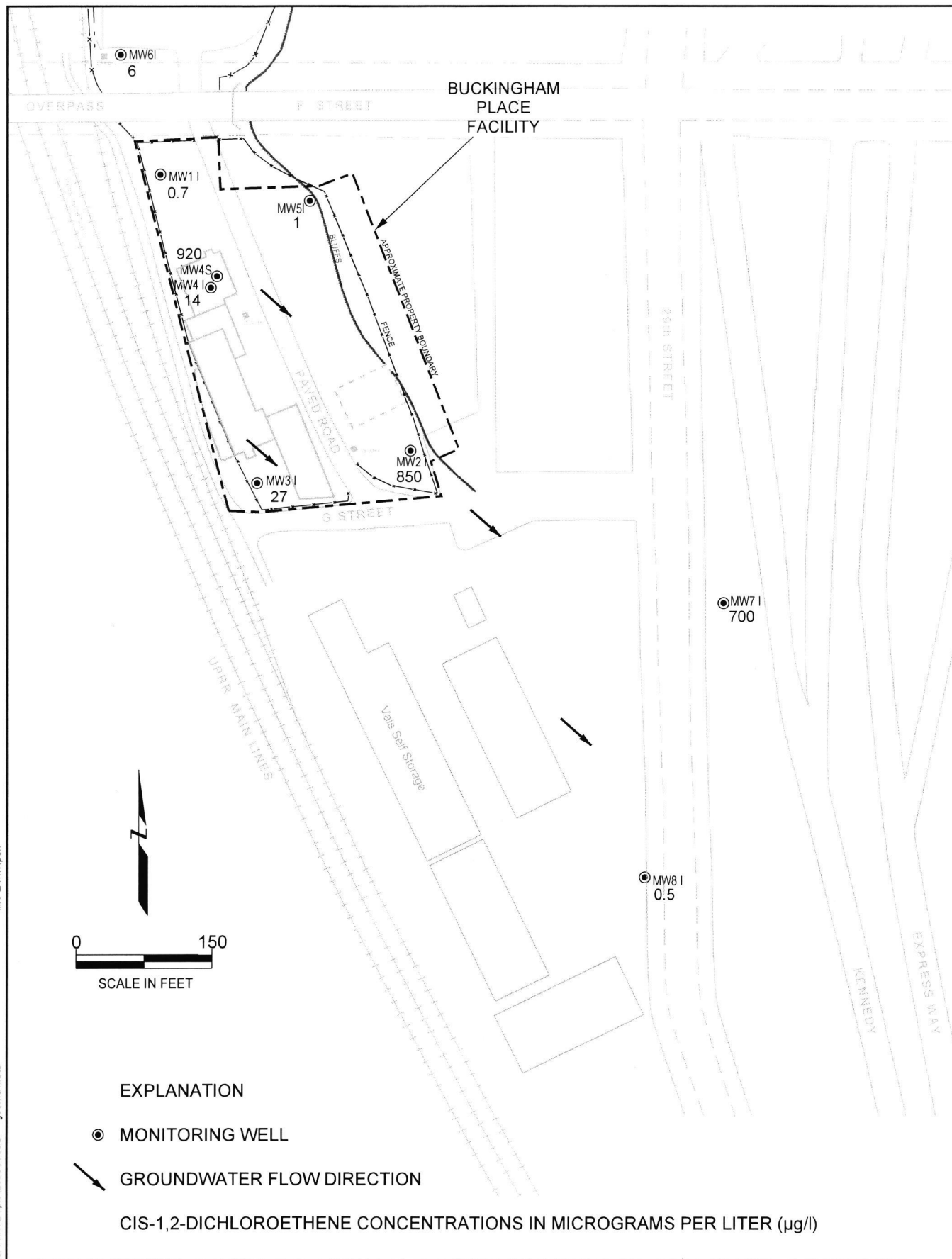
Figure
17



CARBON TETRACHLORIDE CONCENTRATIONS IN GROUNDWATER
MARCH 1999
4120 Buckingham Place
Omaha, Nebraska

Project No.
4133.000

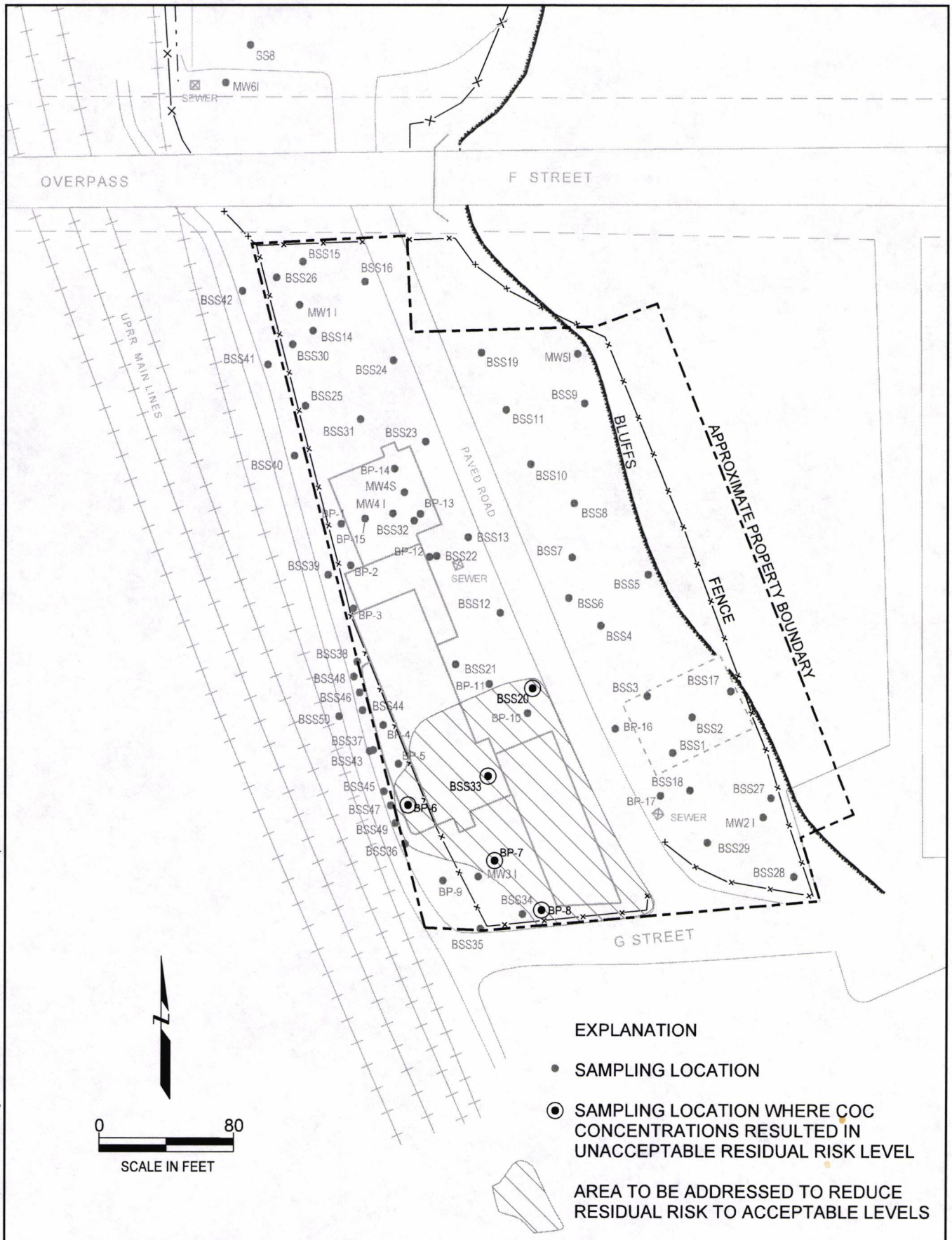
Figure
18



CIS-1,2-DICHLOROETHENE CONCENTRATIONS IN GROUNDWATER
MARCH 1999
4120 Buckingham Place
Omaha, Nebraska

Project No.
4133.000

Figure
19



AREA TO BE ADDRESSED BY SOIL CORRECTIVE ACTION
4120 Buckingham Place
Omaha, Nebraska

Project No.
4133.000

Figure
20